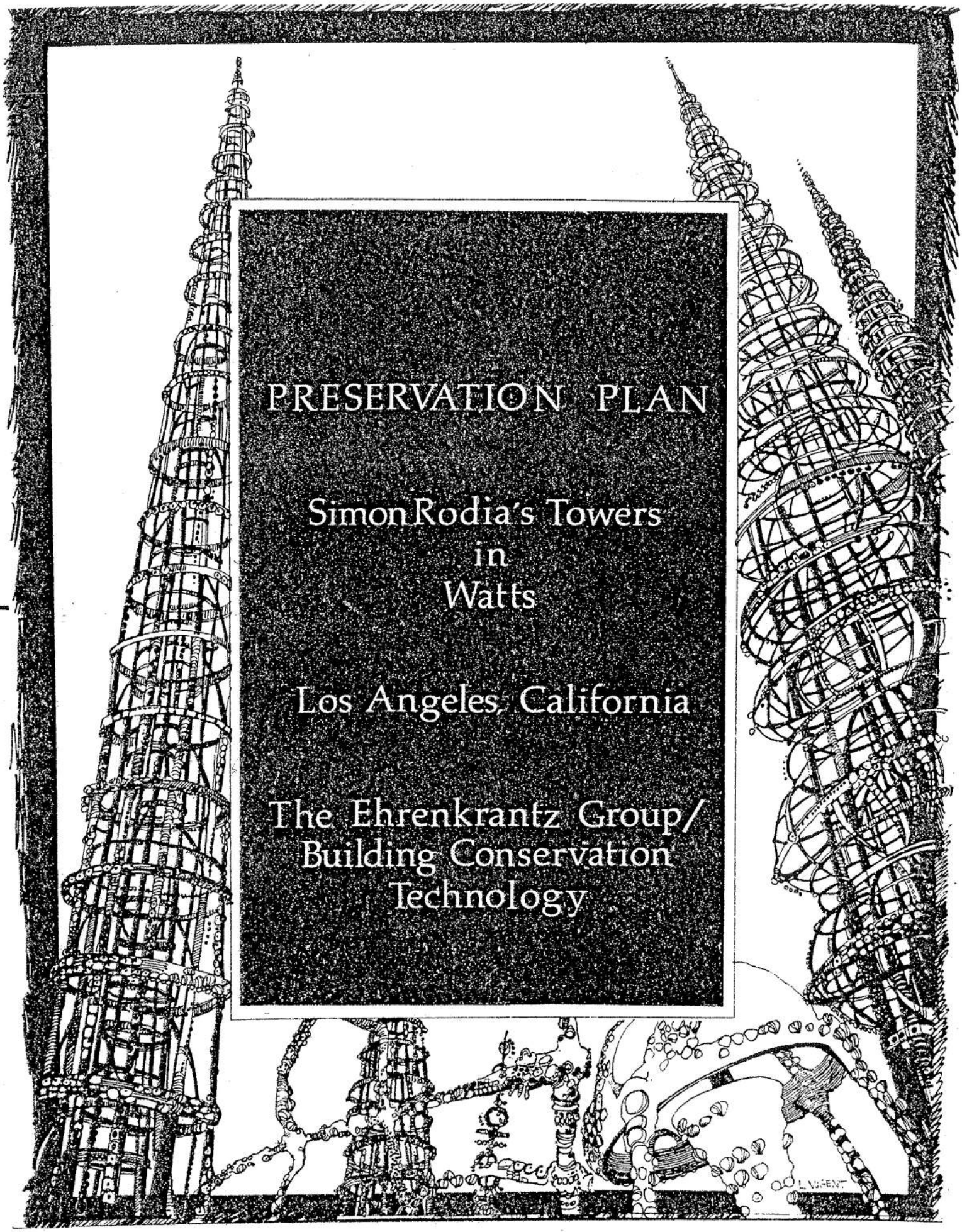

PRESERVATION PLAN

Simon Rodia's Towers in Watts

Los Angeles, California

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Building Conservation Technology

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PRESERVATION PLAN

FOR

SIMON RODIA'S TOWERS IN WATTS

Los Angeles, California

Prepared for:

The State of California
Department of Parks & Recreation
Sacramento, California

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PREFACE

This Preservation Plan deals with the past, the present and the future. We have tried to make sense of the past, or rather the records and recollections of the past from many sources, some of them new. This work can never be complete. Apart from Sam Rodia's whimsical delight in misleading those enquirers for whom he had no time or in whom he had no interest, the historian must confront the complex folklore of the Towers with little recourse to an absolute standard of truth. While many facts are probably now established, many half truths or untruths certainly remain. We hope that the organization we have brought to the archive will help future scholars, and that our index will be made available to them by the Committee for Simon Rodia's Towers in Watts (CSRTW in this report), into whose care we offer it.

In terms of the present, we have studied, analysed and discussed the current work being undertaken by the California State Department of Parks and Recreation. The Emergency Stabilization work is impressive, and in particular Ward Treadwell's sensitive and intelligent approach to the work has provided a first-class foundation, a recouping on past neglect, upon which future work can build with confidence. The example of that work in place on the Towers served to focus our discussions about stability, historical accuracy, and materials. Despite some recommended departures from the current techniques, minor in nature, the fact of having the results of Ward's work observable on the Towers was a great help to us in reaching our conclusions.

As for the future, we feel that the review process by interested parties in the course of our work helped to direct all of us towards some shared objectives, as CSRTW put it a "middle ground," between the technical and aesthetic issues. In our recommendations for future repair and maintenance we have been conservative in terms of technique, emphasizing proven methods yet leaving the door open to new techniques as they become proven. With minor exceptions our approaches to structure and to materials are very close to Sam's originals, which is as it should be. The product of his intuitive genius has, after all, withstood the test of time remarkably well. Despite corrosion and neglect, the Towers still stand, they are reparable, and they continue to inspire awe. In other words they are fully functional, as all great art is.

The Towers fully deserve the attention they are receiving and more, we believe. We are ready to accept as Sam Rodia apparently did, that they need constant repair and maintenance. It was not always so, and it may not be so again in the future. Meanwhile we have learned to share with those who have admired them for longer than us, the urgent feeling that the Towers must be maintained, that they are too important to ignore again.

A very large number of people have helped make the Preservation Plan, and we thank them all for their time, their efforts, and their recollections. CSRTW holds a record of all participants in this piece of work. In addition, this is a place to record the contributions of those directly involved in the work:

For The Ehrenkrantz Group/Building Conservation Technology: Andrew Rabeneck - Project Manager, Mary Oehrlein - Architectural Conservator, Pamela Hawkes - Conservator, Sandra Suominen - Researcher, and Judith Vaughn - Administrator. Our consultants included John Kariotis and Nels Roselund for

structural engineering, Bernard Erlin for materials testing and analysis, and Don Pfeifer and Stella Marusin of Wiss Janney and Elstner who were unshrinking in their support of the water repellent testing and consulting.

For the State Department of Parks and Recreation: Earl Carlson - Supervisor, Architectural Section, and Steade Craigo - Project Architect.

For the Office of the State Architect: Gerald Stanley - Project Manager, and Ward Treadwell - Restoration Specialist.

For background regarding Rodia's family, Brad Byer's assistance was most benificent.

For the CSRTW we must mention Bud Goldstone, Mae Babitz, Ray St. Francis, Christy Johnson, and Jill Dolan.

For the City of Los Angeles: Forrest Scott, Rodney Punt, Paul McCarty, and Mason Dooley.

Last but not least we mention John Outterbridge, Director of Watts Towers Arts Center whose hospitality allowed us to meet at the Arts Center, and whose insights on the Towers in their community setting will be so important to their future.

THE EHRENKRANTZ GROUP/BUILDING CONSERVATION TECHNOLOGY
4 February 1983

TheEhrenkrantzGroup

PART ONE:
REVIEW AND ANALYSIS OF EXISTING CONDITIONS

I. HISTORICAL DATA

Figure 1 Rodia's house, c. 1930. Note original configuration of walls.

INTRODUCTION AND PROJECT SUMMARY

A. PURPOSE OF REPORT

Much of Simon Rodia's effort, until he ceased work on his Watts Towers in 1954, consisted of painstaking and persistant repair. He responded to cracking and deterioration as it happened. During the period of subsequent neglect, more than twenty years, deterioration accelerated and compounded, sometimes aggravated by well intentioned but inappropriate ad hoc repair. Finally, in 1979 the California Department of Parks and Recreation commenced emergency stabilization of the towers and systematic repair. But there is much ground to make up before the towers' condition can be declared "stable," before a plateau is reached beyond which systematic routine repair and maintenance will suffice.

The purpose of this Preservation Plan is to provide guidelines for continuing and completing emergency stabilization and for on-going maintenance. The Plan includes: historical information about Rodia, his structures, and earlier repair activity; an evaluation and condition survey; testing and structural analysis; and recommended treatment including specifications for repair and maintenance.

B. PROJECT METHODOLOGY

The Preservation Plan is presented in two parts which correspond with the phases of work undertaken in its preparation. These phases are summarized below.

C. PHASE ONE

Phase One consisted of review and analysis of existing conditions. Major activities during this phase were:

1. Data Collection

a. Historical Data - Historical materials concerning Rodia and past activities effecting Watts Towers were collected and reviewed. A historical summary was developed which included background information, repair and restoration activity, annotated footnotes, bibliography, and recommendations for additional research.

b. On Site - A conditions survey and analysis of materials and structural condition was made, in addition to a review of the repair materials and methodology employed to date.

c. Laboratory Testing - Selective testing of original and repair materials was conducted. This testing, by Erlin Hime Associates, consisted of petrographic and chemical studies of mortars from Watts Towers. The purpose was to determine original characteristics and changes due to deterioration in order to determine causes.

2. Evaluation

During Phase One, evaluations were made of recording techniques, including photogrammetry, current repair techniques, recommendations for modifications to current repairs, and recommendations for further research.

3. Review Meeting

Information obtained during the course of Phase One was presented at a meeting with representatives from the State, City of Los Angeles, and the Committee for Simon Rodia's Towers. All comments were considered and incorporated into subsequent work.

D. PHASE TWO

Recommendations for unrepaired damage, structural analysis, on-going maintenance, and additional laboratory testing of repair materials were developed during Phase Two.

Major activities were:

1. Recommended Treatment of Unrepaired Damage

a. Review of Current State of the Art Technology - A number of available technologies were reviewed and compared with those currently used or proposed for Watts Towers. These included enclosure, replication in stable materials, cathodic protection, and water repellant coatings.

b. Laboratory and On-Site Testing - In addition to tests on water repellants and crack filling elastomers conducted by John Twilley, Wiss, Janney, Elstner and Associates were retained to test seven different types of sealers as protective coatings for concrete construction. The objective was to compare sealers or water repellents under controlled conditions in terms of water and water-vapor permeability and effectiveness as chloride screens. Test results indicated that the Chemtrete BSM-40 material showed the best performance of the seven tested sealants.

c. Structural Analysis of the Towers - A thorough structural analysis of the Towers was conducted by Kariotis and Associates identifying those members with highest critical rating with respect to lateral loading. Criteria were developed to identify members which required complete repair, replacing only ornament. Less critical members would be repaired using original stucco coating and ornamentation.

d. Recommendations - Repair philosophy, a prioritized schedule, and specifications were detailed. The specifications and schedule focused on repairing critical members of the structure first to ensure structural stability and safety while maintaining the artistic integrity of the Towers.

E. ON-GOING MAINTENANCE

Upon completion of emergency stablization, continuing maintenance will be very important. Maintenance requirements outlined during this phase included the need to repair recurring weaknesses, as well as routine housekeeping.

The maintenance program also addressed philosophy, tasks, maintenance schedule, personnel, a handbook as a recommended method of record keeping, and protective measures.

I. HISTORICAL DATA

A. INTRODUCTION

The Watts Towers, constructed in Los Angeles by Simon Rodia from the 1920's to the 1950's, have mystified observers since the work began. Public opinion has progressed from considering the Towers as local curiosities to acclaiming them as unique examples of twentieth century folk art. Visitors and supporters express strong and varied views about why the Towers were built, what they represent and what shold be done to preserve them.

The mass of conflicting information makes constructing an accurate, objective history of the Towers quite difficult. Although vast quantities of written material on the Towers exist, much repeats initial accounts or reinterprets partial evidence with no concern for primary source documentation. Press coverage typically focuses on the controversy and politics surrounding the Towers and seems to prefer colorful anecdotes to hard facts. Rodia himself contributed to the problem, seeming to delight in testing the gullibility of reporters with his quaint and frequently conflicting pronouncements.

The following is a capsule summary of background information as it has been documented. Footnotes have been provided as a means of discussing the discrepancies surrounding the data. The fact that these notes are more extensive than the text is the clearest indication of the predominance of supposition and rumor over truth where the history of Watts Towers is concerned.

B. SIMON RODIA AND HIS TOWERS

Simon Rodia[1] was born in Italy sometime between 1872 and 1893.[2] In adolescence, he immigrated to the United States and settled on the East Coast, probably in Pennsylvania. After working for some time as a construction laborer, repair man, miner, tile setter, and nightwatchman, Rodia migrated west.[3] He settled in the San Francisco Bay area, reportedly married and had children.[4] At this time, he worked primarily in construction and tile setting.[5] Sometime in the early 1900's, as his marriage may have become strained, Rodia left for Southern California. During this period it is believed that he traveled to Mexico and worked in the Long Beach, California area.[6] Finally, in the 1920's, he moved to Watts, a small rural community near, but not yet part of, Los Angeles, California.[7]

Rodia purchased a triangular plot of land - measuring 137 feet on the south side, 69 feet on the west and 151 feet on the northeast side - at 1765-69 E. 107th Street between Graham Avenue and the Southern Pacific Railroad right-of-way. There, for motives that may forever be obscured by the mythology of the Towers, Rodia began a series of fantastic concrete constructions.[8]

The precise construction history is uncertain, since few people noticed his activities until 1937, when Charles Owens and Joe Seewerker wrote a "local color" story for their "Nuestro Pueblo" column in the Los Angeles Times.[9] According to one source, Rodia said "I had a patio. The house was an old barn. I plastered outside and made a porch, then I started a

fish pond, the ship in the corner."[10] The south side of the house is shown in early photos of the site (Fig. 1); it burned in the 1950's, leaving only the chimney and parts of the exterior walls. Owens and Seewerker stated that the wall was built first, then the towers, while Rodman declared in 1952 that "the wall around the Towers was not part of Simon's plan...but the local police saw a hazard to climbing children, so the walls were built."[11] Nick Calicura recalls from a visit made in the 1920's that the center and east towers had been built, but not the tall west tower or ground level elements surrounding the Towers.[12] Rodia may have built the Towers incrementally, adding onto a number of elements simultaneously as they grew.

The site today consists of seven concrete-clad skeletal towers ranging in height from 11 to 99 1/2 feet, enclosed on the north and south edges of the property by decorated concrete walls. Other elements in this concrete "garden" include a gazebo, fireplace, fountains, and garden ledges.

The construction methodology and materials appropriated by Rodia clearly influenced the final appearance of the structures. The armature was sunk into concrete footings, consisting of angle irons, railroad rails and metal pipes. The members were lapped at the ends, spliced with copper wire and covered with expanded metal lath or aviary wire. Mortar was layered over the metal frame and, after obtaining the "right" thickness, the damp surface was decorated with imprinted designs or found objects. These included plates, teapots, shells, rocks, tiles, bottles and mirrors, colorful odds-and-ends picked up by Rodia that form a catalogue of Americana for the 1920's, 30's and 40's.

Working without scaffolds or ladders, Rodia appears to have built many parts on the ground, then fixed them in position by climbing over the previous work. The mortar[12] was carried in a bucket slung over his arm, and the proportion of the ingredients appear to have varied as widely as the color of the mix, although laboratory analysis of mortars used exhibit remarkable consistency. (see Section I.B.2-Testing and Analysis) The configuration of the Towers thus was dictated to a large degree by the span of Rodia's arms and legs.

C. THE TOWERS AFTER RODIA

Over a course of approximately 33 years, Rodia built and maintained the Towers.[13] As the Watts population shifted and early residents familiar with Rodia's activities were replaced with newcomers, Rodia apparently felt harrassed. Outside of Watts, the focus of the Tower's significance was also changing. The Towers, gained status in art circles when Jules Langsner, a Los Angeles art critic, mentioned them in a 1951 Arts and Architecture column.[14] In 1952, William Hale, then a student at the University of Southern California, made a twenty-minute documentary film highlighting Rodia and the Towers.[15] This increased interest about the work.

Rodia stopped working on the Towers in 1954, deeded them to a neighbor, Louis Sauceda, and returned to Martinez, near San Francisco, where he died in 1965.[16] The Towers were unattended from 1954 to 1959. During this time, Rodia's residence burned to the ground. The fire did not harm the Towers, although vandalism and lack of maintenance increased their rate of deterioration.[17] On February 5, 1957, Inspector Overlin, Inspector of the

Conservation Bureau, Department of Building and Safety, posted "Dangerous Do Not Enter" placards on the building and issued a demolition order.[18] Sauceda was able to sell the Towers for $1,000 to Joseph Montoya in the Spring of 1957.[19] Montoya, unable to develop the Towers as a taco stand as planned, in turn sold them for $3,000 to William Cartwright and Nicholas King in May 1959.[20]

Cartwright and King, with the assistance of architects Ed Farrell and Herbert Kahn, began plans to build a caretaker's cottage and maintain the Towers as an art monument.[21] They discovered the 1957 demolition order issued by the L.A. Department of Building and Safety to Sauceda. At this time, the Department of Building and Safety's Conservation Bureau, headed by Harold Manley, reinitiated condemnation proceedings.[22] This began the first major controversy concerning the Towers, occurring five years after Rodia had departed.[23]

Considered a cross between sculpture and architecture, the Towers departed from traditional construction methodology, and thus, rules and regulations.[24] The Department of Building and Safety's Conservation Bureau found this unacceptable however, concluding that the Towers, as an "attractive nuisance," endangered the safety of residents nearby.[25] Manley, under the provisions of Section 96 of the Los Angeles Municipal Code, therefore proposed holding a formal hearing "to prove that these towers are dangerous and structurally unstable."[26]

Cartwright and King meanwhile had begun to organize support to save the Towers. They were assisted by the Los Angeles County Museum of Art and advised to form a nonprofit group which was and is still entitled the Committee for Simon Rodia's Towers in Watts (CSRTW).[27] The Committee, represented by attorney Jack Levine, supported the Towers and their owners during the demolition hearing.

The hearings were held July 6 through July 23, 1959,[28] but a structural test in October determined the real outcome. The case received considerable publicity and the proceedings total 1,263 transcribed pages.[29] The City argued that the Towers endangered the public according to Article 6, Chapter 9 (Los Angeles Municipal Code) and, as they could not be reasonably repaired, should be torn down. In response, Levine maintained that the Towers as sculpture were not subject to the Building Code, and therefore outside the jurisdiction of the Department of Building and Safety. Although this point was denied, other testimony illuminating the unorthodox nature of the Towers strengthened the need for an unconventional resolution. Finally it was agreed that the only way to resolve the difference between the divergent opinions and calculations of the engineers representing the City and the CSRTW was to perform a test of lateral loading on one of the towers.[30] The test was designed by Norman J. Goldstone, engineer for the CSRTW. Though the towers survived the test and the structures were declared sound, the settlement of the hearings after the test required that all the towers be repaired to eliminate danger (See History of Repair following).

CSRTW, relying on volunteer help, occasional grants, donations, and membership drives, maintained the Towers from 1959 to 1975. They reportedly waterproofed and repaired the Towers as necessary, and collected admission fees to cover expenses.[31] In addition to the Towers'

upkeep, committee members organized free art classes for community residents, drawing on the inspiration of the Towers. They built the Watts Towers Art Center, later donated with the Towers to the Los Angeles Department of Cultural Affairs. In March 1963, Watts Towers was declared an historic monument by the Los Angeles Cultural Heritage Board and listed on the National Register of Historic Places.[32] The Watts Riots in August 1965, although causing widespread destruction in the vicinity, left the Towers unharmed.[33]

As resources and help became limited, CSRTW decided to donate the Towers to Los Angeles in 1975, with the stipulation that CSRTW would monitor the Towers' well-being and the City would perform necessary repair work.[34] In 1978, the City, under pressure by CSRTW to abide by the agreement, contracted Ralph St. A. Vaughn to perform repair work.[35] This restoration caused further controversy because it was not considered acceptable, and in some cases was actually damaging.[36] Work stoppage was ordered in October 1978. Legal suits relating to this repair activity appeared and remain unresolved.

The State of California assumed responsibility for repair work in May 1979. The Conservation and Maintenance Plan outlined emergency and stabilization tasks using the remainder of the $207,000 budgeted for repairs.[37] Upon completion of this work, the Towers will be returned to Los Angeles for future maintenance and upkeep. Assembly Bill 990, passed in August 1980, dedicates financial support to restore this local landmark. It was concluded that a systematic preservation plan, determining procedures for restoration, materials testing, and long range maintenance be developed to enhance the restoration. This was undertaken by The Ehrenkrantz Group in 1982, and is the subject of this report.

D. REPAIR AND RESTORATION WORK AT WATTS TOWERS 1957 - present

The structures comprising Watts Towers appear to have presented materials failure problems even before Simon Rodia completed work on them. Inspectors for the L.A. Department of Building and Safety, who had monitored the site since the late 1940's, reported that no serious deterioration was evident through 1957.[38] Rodia had "kept up a constant program of maintenance and repair"[39] from 1948, when he completed most work on the Towers, until his departure in 1954. By 1958 however, vandalism had taken place; in addition, "wide cracks and spalling were making the corroded reinforcing visible."[40] A catalogue of the cracking was prepared by the building inspectors in 1959 in connection with a suit filed by the City at that time for demolition of the Towers.

Hearings were held on the safety of the Towers between July 6 and July 23, 1959. (See Appendix 2.) Testimony included 3 sets of engineering calculations, all based on differing assumptions about the structural make-up of the Towers. As a result of predictions based on the assumption that the structure acted like reinforced concrete rather than steel (made by Norman J. Goldstone), engineer for the CSRTW, the Department agreed to test the safety of the structures by applying a lateral load of 10,000 pounds at a height to produce 330,000 ft. lbs. of moment at the base for a total of 5 minutes. The test was designed by Goldstone and undertaken in October of 1959; the tower held for 90 seconds, when a beam bent

preventing the apparatus from exceeding the 10,000 lb. test load. The representative of the Building Department agreed nonetheless that it had satisfactorily proven "that with respect to dead and live loads, wind loads, and earthquake loads, the structures are safe and are not presently likely to partially or completely collapse."[41] The Department agreed to permit the Towers to stand, provided that necessary repairs be completed.

These repairs were specified by the Department to include the following:

1. Replace all obviously broken and missing members.

2. Replace all members which have deteriorated beyond the point of repair.

3. Fill all cracks possible with portland cement plaster.

4. Cover all surfaces of the structures with a waterproofing sealer to prevent intrusion of water.[42]

Little documentation is available on this rehabilitation work, which appears to have taken place in 1960 and 1961. Some crack filling and stucco replacement had occurred prior to the structural tests in the fall of 1959.[43] A "Notice to Comply" dated September 2, 1960 ordered the CSRTW to stop all repair work underway at that time, to "remove all patchwork done with interior grade plaster," and to execute all repairs with portland cement.[44] Another memo dated August 28, 1962 noted that the Towers had been "sprayed," presumably with a waterproofing agent, though the type of material is unknown.[45]

The next documented repair work on the Towers was carried out by Tom Wills in 1965 and 1967. (See Appendix 4.) This consisted of filling 1500 cracks and dissection and re-wrapping of "a few joints." Most of the cracks were filled with a mortar mix made up of 3 parts pre-mix sand, 1/2 part portland cement and "just enough water so that the mix would hold its shape when squeezed." All "serious areas of repair," all areas "where the original concrete is of a poor quality," and one lower rib located directly over pedestrian traffic were treated with an "epoxy water-soluble concrete" called "Thorite."[46]

Between 1965 and 1975, Williams Waterproofing Company was given an annual contract for filling cracks and waterproofing. In the years following the donation of the Towers to the City of Los Angeles, only basic custodial work took place. The Committee observed with alarm that neglected cracks were permitting water to come in contact with the ferrous armature, with consequent corrosion and spalling of the concrete cover.[47]

Norman Goldstone reported in March of 1978 that:

> "long cracks, some more than 5 feet, with gaps measuring from 1/8 to 1/4 inch, were seen on 10 or more vertical legs of the 3 tall towers. The situation is particularly serious since the tall tower legs get their strengths from the combination of cement cover and steel reinforcement. ...Therefore, an immediate danger to the Towers exists, namely that loads caused by wind or seismic forces may buckle

the Tower legs which have been weakened by loss of the continuity of their cement coverings."[48]

Despite substantial HUD grants to the Municipal Arts Department for site improvements and rehabilitation, the City refused to spend the money and in 1978, closed the Towers to the public.

In March of 1978, Ralph St. A. Vaughn was hired to prepare and supervise a "preservation plan" for the Towers. (Note: Vaughn's drawings appear to reproduce earlier sketches from the Department of Building and Safety.) Though the City signed a $207,000 contract with Vaughn on May 17, 1978, criticism about Vaughn's qualifications and recommendations was gathering force. On July 18th and 20th, officials from the City, the State (which on May 19th had accepted title to the Towers), local museums, the AIA and the CSRTW met to hear Vaughn's plans and criticisms. In response, Vaughn prepared an addendum to the specifications.

Nonetheless the City paid Vaughn $15,200 for his Preliminary Report and on August 1, he began Phase 1 of the work. Observers for the CSRTW noted no scaffolding in evidence and watched work crews "climbing through West and Center Tower prying off decorative surface with putty knives and wrenching off structural braces by brute force."[49] The State then stopped work and met with Vaughn, who agreed to build the required scaffolding. Work was shut down again on October 4th and on October 27th, the CSRTW filed suit against Vaughn, the City and the State, charging that the work done by Vaughn endangered the Towers and its status as a National Register property. Vaughn in turn, filed a "breach of contract" against the State. These cases have not yet been resolved.

On May 1, 1979, the State began emergency work, using the remainder of the $207,000 budgeted for repairs by Vaughn. As spelled out in the "Conservation and Maintenance Plan" (See Appendices 5 & 6), the work crew was hired under the supervision of the Office of the State Architect and was directed to concentrate on "restoring the load-bearing legs, rings and lateral supports."[50] Materials to be used in the work were not specified, as they were still under study by the State and by the conservation staff of the J. Paul Getty Museum, which had been brought in as advisors by the CSRTW. William Firschein, an architectural preservation consultant on the Board of CSRTW, Norman Goldstone of the CSRTW, and Steade Craigo, Architect with the California State Office of Historic Preservation also provided input at this time.

The basic repair sequence in use is outlined in Appendix 7 and detailed in daily logs kept on the site. "Before" and "after" photographs of the work have been prepared and with the daily descriptions, are keyed to a system identifying individual parts within the Tower complex. (See Section II.C.)

In December and January of 1980, a number of caulking compounds were applied to cylinders with 3/16 to 1/4 "assimilated fissures" (sic) prepared on site and then subjected to tension and compression tests at Smith-Emery Laboratories. Materials included:

1. Tremco ("mono" or "small joint" sealant);
2. Vulkem gun grade;
3. Vulkem pour grade;
4. Getty Museum casein-lime mix;
5. Combination Vulkem gun grade and Tremco, "where the face of the fissure is filled about 1/4" deep and the remaining area filled with Tremco," and,
6. "Common Cement Sand mix."[51]

The daily log for March 12, 1980 noted, however, that "Today we started filling small cracks with Tremco,"[52] while an entry on August 6, 1980 reads "Embedments were re-adhered to the center tower with Vulkem sealant."[53]

In the Summer of 1981, tests on joint sealants and waterproofing materials were initiated under the direction of John Twilley and Norman J. Goldstone. Results of these tests are discussed in Section IV.B.

E. FOOTNOTES

1. Simon Rodia has been referred to by many other names. Joe Seewerker and Charles Owens referred to him as "Simon Rodilla" in "Glass Towers and Demon Rum" (Los Angeles Times, April 28, 1937). Jules Langsner called him "Sam of Watts" in Arts and Architecture (58 (July 1951):23-25). Seldon Rodman called him "Simon Rodilla" in "The Artist Nobody Knows" (New World Writing No. 2, 1952). Urlich Conrads and H. Sperlich mention him as "Simone Rodilla" in The Architecture of Fantasy (New York: Praeger & Co., 1962). Mercedes Garcia, a neighbor interviewed by Professor John L. Dunbar of Claremont Men's College for his Paper, "The Trial," recalled him as "Don Simon." An article in the Los Angeles Free Press, (July 23, 1965), mentioned that his baptized name was "Sabatino Rodia." His tombstone in Martinez, California reads "Sam Rodia" (order to Vallejo Monument Co. from Leonard Sullivan, March 20, 1966).

2. The exact date and location of Rodia's birth is unknown, although various accounts place it between 1872 and 1893 in Italy. His "Family Record of Deceased" lists the birthdate as April 15, 1875 (Brad Byer). A social security application filled out by Sam in 1937 sets his birth on April 15, 1886 in Rome, son of Frank Rodia and Angelina Rosen. (U.S. Social Security Act, Application for Account No. 568-03-6787. BB.) Rodman (p. 153) uses 1898; Langsner ("Sam of Watts, "Art and Architecture, Vol. 58 (July 1951), states that he was born in Rome in 1879. The L.A. Free Press (July 23, 1965, p.1), listed "April 15, c. 1878, in Serena, province of Arellino, Italy, son of Francisco and Avelina Rodia." C.J. Laughlin repeats this reference in "A Pleasure Dome in Los Angeles," The Saturday Book (No. 27 (1967), p. The Watts Towers, an information pamphlet prepared by the Committee for Simon Rodia's Towers in Watts, concurs while using 1879 as the birthdate. Paul LaPorte, formerly with Immaculate Heart College in Los Angeles, gives the date as 1880 in Italy near Naples in his biographical sketch, "The Man, The Work" (1962). In a letter to Sunset Magazine (May, 1965), Mrs. N.A. Walberg, R.N. of the Alhambra Convalescent Hospital gave Rodia's age at the time as 95, placing his birth around 1870.

3. Reports of Rodia's life before building the Towers are largely conjectural, except where they may be substantiated by employment records or family accounts. Brad Byer, son of Mary Lou Byer, one of Rodia's nieces, maintained that Rodia's parents sent their three sons to the United States to avoid the Italian conscription affecting males 14 years and older. Rodia, apparently the youngest, was between nine and fifteen years old when he arrived in the U.S. around the turn of the century. (Rodman, p. 153). Langsner, (Arts and Architecture, 1951), J. Bronowski, (Ascent of Man (Boston: Little Brown & Co., 1974), p. 118), and The Watts Towers all use different dates for the immigration.

   Nick Calicura, a nephew, states that Rodia went to Pennsylvania, near Paoli to live with his older brother, Ricardo Rodia (known as Dick Sullivan), and work in the mines. Sullivan was later killed in a mine explosion. Jeanne Morgan, one of the founding members of CSRTW,

visited Rodia in Martinez and reported in the Fourth Annual CSRTW Newsletter (September 1964, p. 7) that "his brother, who was killed by a dynamite blast, was named Dick." In contrast, Conrads (p.164) relates that Rodia emigrated around 1900 and "soon found work as a skilled tile setter." In another account, later qualified as "a slightly inaccurate portrayal," Claire Biane Frith ("Nuestro Pueblo," 1959, p. 1) stated that Rodia had "steady employment as a repairman for a steam elevator company which moved west with Rodia following," as of 1898. Byer has collected Rodia's union cards for the International Aid Carriers Building and Common Labor Union (1946) and the Amalgamated Meat Cutters and Butcher Workmen (1947), as well as letters of recommendation from the Markwell Building Company in Long Beach (1920) and architect Charles F. Plummer in Los Angeles (1932). The latter said Rodia's work "included the handling and placing of both plain and reinforced concrete...special mention should be made of his industry - a very busy man and tireless worker." (From collection of materials held by Brad Byers. See Note 3.)

4. Rodia's relationship with women and family are additional facets of his life that have received conflicting reports. According to Nick Calicura, before leaving northern California, Rodia lived in Albany, California with a wife, (BB) some sons and a daughter. The register of attendees at his funeral included "Alfred F. Rodia and Frank G Rodia, sons." He worked for a construction company until he "left that wife in Albany and ran off to Mexico, where he became mixed up with a Mexican girl, some hot-blooded brothers and a revolution." (Nick Calicura to Dunbar, "The Trial," p. 34). Calvin Trillin ("I Know I Want to Do Something," The New Yorker (May 29, 1965), p. 104), states that, according to Rodia's eldest nephew, Rodia had married in Martinez, had three children and then left the area after a bitter separation from his wife. While the daughter died young, Rodia later denied the existence of the other children. Mercedes Garcia ("The Trial," p. 35), mentioned that he may have married a Carmen who "cleaned him out head to toe" after two or three months. Robert Ryan ("Sam Rodia and the Children of Watts," Westways Magazine (August 1967), p. 1 of reprint), described Sam of the 20's and 30's as an "unattached gay blade who squired the girls of the neighborhood and drove his 1927 Hudson touring car about at a tremendous speed." According to Byer, his aunt Angie Alexander, who cared for Rodia when they both lived in southern California, feels that these views of his relations with women are unlikely, insisting that when he was building the Towers, he ignored matters related to personal hygiene and would not have been attractive to females. This was the appearance that Jules Langsner recalled to Trillin. Rodia's own statements concerning marriage, made during interviews with Mae Babitz and Jeanne Morgan, reinforce this: "Cannot marry but once... Is not true? Once you marry, once only, no?" (Gerald Winerman, "Simon Rodia--Immigrant, Beachcomber, Artist," (1961), p. 19).

5. Calicura states that Rodia and Nick's father worked in stone quarries in the El Cerrito hills for the Spring Construction Co. After this, he worked in various construction-related jobs around Oakland.

6. According to the Garcias, Rodia occupied a house in Long Beach, where he built a merry-go-round and decorated a wall with arches, before moving to Watts. At demolition, they reported that "the house went down in one blow, but it took three days to tear down Rodia's cement constructions," (Dunbar, p. 37). Bud Goldstone, a retired engineer who has been interested in the Towers since 1959, especially their structural characteristics, was unable to see the Long Beach work before its demolition, but dates it around 1912. The letter of introduction from the Markwell Building Company of Long Beach, dated June 19, 1920, supports this theory of his whereabouts.

   At this time many people also believe that Rodia served in a war, presumably World War I. Rodman stated that Rodia was discharged from the Army Corps of Engineers in 1918 after service in France. A quote attributed to Rodia by Dunbar conflicts with this: "I no was in the army...was in the hospital, where we had a Spanish troops that was a-dying...sometimes it make-a me cry." (p.36.) Nonetheless, Rodia related his war experiences to Committee members, including Jeanne Morgan, who reported in the Fourth Annual CSRTW Newsletter (pp. 7-8), that Rodia was "sent by the Army to Houston, Texas to a big hospital...where they put him on a job running the elevator and he helped carry up and down all the people dying from the Spanish flu." Finally, Calicura felt he would not have served in the military because its emphasis on regimentation went against his personal grain.

7 Francesca Fideler, ("The Watts Towers", September 1976, p. 5), described Watts in the 1920's as "a small community with its own mayor and police force,...predominantly rural with its chickens and goats and acres of onion fields." It was not until May 29, 1926 that Watts was annexed to the City of Los Angeles. This had significance later, as inspectors from the Los Angeles Building Department insisted that there was no building permit or construction plan on record, which would be likely if Watts was not part of the city when Rodia began his construction.

8. Both an accurate start-up date and the sequence of construction are undetermined. 1921 is the date embedded in the walls of the work, yet that may have been arbitrarily picked by Rodia at a later date. Calicura does report seeing the Towers under construction during a visit in 1923 (Byer tape) and Rodman maintains that the first tower was about twenty-five feet high in 1922, (p. 154). One of the outstanding questions has been whether Rodia sought permission from the local authorities for his project. According to Langsner, (Arts and Architecture, pp. 23-25), Rodia maintained that he drew up plans and presented them to authorities in Sacramento. During a tape interview with William Hale in 1952, Rodia stated "Yes, I got 'em...yea, I got a permit from Los Angeles, I gotta letter from Sacramento, too..." Without seeing the actual documents, however, this answer cannot be substantiated.

9. The Owens and Seewerker article marks the beginning of a long series of published reports exploiting the "colorful" nature of the Towers, frequently at the expense of the truth. These articles presented a range of theories on Rodia's motivation and influences, on what the

Towers represent, why Rodia left in 1954, and where they stand in the history of art. Following are some theories on Rodia's motivation:

"I was drinking. No wife, she passed away ... no daughter. I was drinking three days and nights, I really drank, so I started work on Towers. No more drink -- just built Towers." Rodia to Kate Steinitz, "A Visit to Martinez, June 2, 1961."

"I had it in my mind to do something big, and I did." Rodia to Langsner, Arts and Architecture, July 1951, pp. 23-25.

"He wanted to do something to satisfy himself." Nick Calicura as interviewed by Brad Byer, January 1982.

"...So I build my wall so much I am forget to drink. Then I am think of towers and not to drink." Rodia as quoted in Nuestro Pueblo, 1940, p. 56.

"I wanted to do something for the United States because these are nice people in this country." Rodia, quoted in Watts Towers Pamphlet.

"He lived in a self-enclosed world, and he had a fantastic obsession - a monument. He wanted to be remembered." Langsner to Trillin (New Yorker, p. 75).

"Some say that he murdered his wife and that this is his penance." A neighbor to Rodman (p. 156).

"His gigantic protest against the community which epitomizes our materialism is effective precisely because it has no possible use save beauty and because its creator is content to live and die within what is intended wholly for the pleasure of others." Rodman (p. 157).

"Perhaps Sam had the desire to counteract with his purposeless towers the commercial oil towers growing like threatening uncanny trees on Signal Hill, not far from his lot." Steinitz, L'Arte (October-December 1959).

George Dumpf, an inspector for the L.A. Department of Building and Safety, was apparently told by Rodia around 1947 that the towers at 99 and 101 feet in height were built to commemorate Highways 99 and 101. (L.A. Dept. of Building and Safety, Testimony Documents, June 18, 1959.)

"Something to make a pretty scenery, I think, so people would come and make that place famous, at least around here." Boy's voice from 1952 Hale tape, transcribed in Trillin, (New Yorker, p. 80).

Francesca Fideler notes that the Towers were suspected as a Japanese radio relay for Tokyo Rose during World War II, (p. 6).

"Perhaps Rodia remembered Italian mosaics, but as far as one can tell, for him environment and need supplanted tradition." W.C. Seitz, The Art of Assemblage, (New York: Doubleday & Co., 1961), P. 73).

"Rodia's aesthetic is a combination of all his travels, experiences and exposure, and his work reflects his Spanish sic influence." (Fideler, p. 5.)

Indian and Cambodian inspiration is cited by the Christian Science Monitor, (May 26, 1956), though how Rodia would have found such sources is unclear.

The inscription on the Towers, "Nuestro Pueblo," has been translated as a dedication to "Our Town," "Our People," "El Pueblo Nuestra Senora la Reina de Los Angeles de Porciuncula," while Rodia apparently translated it to mean "lotsa things, lotsa things." (Fideler, p. 12.)

10. Fideler, p. 3. Early photos, undated, in Bud Goldstone's possession, show changes in the towers.

11. The sketch by Charles Owens in 1937 for Nuestro Pueblo illustrates the Towers with a cross, later removed, on one of the elements and the west or tallest tower only about 60 feet tall, with only a few horizontal bands and cross-bracing between them.

12. Smith Emery test results estimated a proportion of cement to sand, based on the original dry mix, to be 1::4.23 by weight and 1::4.14 by volume. The tests were made on only one sample, and the mortar varies throughout the complex. The tests could not reliably have distinguished lime content. (Test results #P-329435, June 30, 1959. LADBS.)

See: Phoebe S. Goldstone, "Watts Towers Show Structural Capacity of Lathing," Progressive Architecture, (April 1960: 8-13); and N.J. Goldstone, "Structural Test of a Hand-Built Tower," Experimental Mechanics, (January 1963: pp. 8-13). Buckminster Fuller, who began working with reinforced concrete in 1922, visited the Towers in 1960 and observed (Laughlin, p. 107): "Rodia was a master of his material, cement. Rarely have I seen a construction standing as long as the Watts Towers showing so few and so insignificant cracks."

13. Observations in 1948 by V.K. Liila, (Building and Safety File 46474), state that the Towers were completed by then, with Rodia doing maintenance and repair until 1954.

14. Rodia and his work have been compared to numerous others, past and present, by various observers, as follows:

Jules Langsner, Architecture Review, March 1952, p. 202 and Arts and Architecture, September 1959, p. 27-28, notes similarity to Ferdinand Cheval who built his "Dream Palace" in Hauterives, France from 1879 to 1912; Chardin, the 18th Century French painter; and the golden stupas of Siam.

Kate Steinitz, L'Arte, Oct-Dec, p. 5, compares him to Antonio Gaudi (Familia Sagrada and Parc Guell), Georges Braque, and Schwitters.

Barbara Jones, Follies and Grottos, 1949, p. 270, cites Ferdinand Cheval, Josiah Lane, Claude K. Bell, and Cabazon (brontosauros at San Gorgonio Pass) as similar figures.

Clarence Laughlin, ("A Pleasure Done in Los Angeles," The Saturday Book No. 27, 1967), feels the angular shapes resemble a painting by Paul Klee (p. 114) and also sees an affinity with Buddhist temples of Bangkok (p. 107).

Calvin Trillin (New Yorker, 5-29-65, p. 81), notes comparisons to Pointilist paintings of Georges Seurat and to the temple designs of Angkor.

Dunbar, (The Trial, p. 44 and 46), cites similarities to paintings of de Stael and to the Mozambique buildings of Guedes.

William Seitz, (Art of Assemblage, 1961, p. 78), links the Towers to Byzantine mosaics and patterned pavements of Spain in South America.

William Davenport, (Art Treasures of the West, 1966, p. 60), also notes the cultural affinities between Spain and California as influence.

An exhibition sponsored by the Walker Art Center, Minneapolis in 1974 organized collections of contemporary "primitives" called Naives and Visionaries. This exhibit was described by (Emily Genauer, (Newsday, January 24, 1975), as a "spectacle of human beings, old, untaught, and most of them very poor, whose need to rise above and even alter dispiriting, limiting, ugly reality was so tremendous it led them to find the technical skills, the materials, the incredible invention, the sustained vision, even the fabulous physical strength to create monumental works of art of dazzling...quality."

15. Hale's film and corresponding tapes of conversations with Rodia made the Towers visually accessible to many people before Watts was itself accessible by freeway. It shows Rodia on the Towers and records some of his philosophies.

16. Rodia's decision to leave the Towers in 1954 prompted further conjecture:

Some maintain that Rodia left them as the "purist artist interested only in the act of creation, not in the product." (Trillin, p. 81.)

Trillin and a neighbor, Angelina Marin, point to the frustration Rodia developed when "confronted with increased harassment, vandalism and maltreatment by neighborhood kids." (pp. 81-82.)

Steinitz felt Rodia abandoned the Towers "feeling his strength declining." (Art Forum, August 1962, p. 17.)

The Watts Towers suggests the possibility of "some strong disappointment." (p. 4.)

Paul LaPorte saw opposition and lack of interest in his work as a reason for leaving.

According to family accounts by Byer and Calicura, Rodia fell ill for three days without anyone noticing his absence. Once he recovered, he decided it was time to return north where he could live out his life with his relatives.

17. Harold Manley, (Memo May 30, 1959, File X46474 LADBS), explained that the first official notice of the Department of Building and Safety was made when the Towers were inspected in 1956 in the course of the Watts Rehabilitation Program. This led to the Notice to Comply, issued by Inspector Overton (File X46474 LADBS), stating: "Barricade the fire-damaged dwelling and the dangerous towers from ingress by unauthorized persons. Demolish and remove the premises on or before March 5, 1957." In the May 30th memo, Manley appended his infamous statement: "Personally, I think this is the biggest pile of junk outside of a junk yard that I have ever seen."

18. See Job Progress Statement February 5, 1957, LADBS.

19. Ibid., March 5, 1957.

20. Montoya had the building demolished by July 11, 1957, but did not proceed further with his plans. (Ibid., July 11, 1957.)

21. Ibid., May 21, 1959.

22. Manley, Chief of the Conservation Bureau by 1959, had seen the Towers as early as 1948 or 49. He decided then that the Towers appeared to be dangerous and should be ordered demolished (LADBS). No official action occured until 1957. See note 17.

23. When located and informed of the status of the Towers, Rodia did not appear interested. He reportedly stated: "Just tell them to do whatever they please with them." (Los Angeles Examiner, May 25, 1959.) This dismayed his supporters.

24. Confusion in defining the structural capability of the Towers was amplified by Manley's statement (LADBS files) that "the Towers because of irrational construction and planning do not lend themselves to a rational engineering analysis."

25. Manley's reference to the Towers as an "attractive nuisance" does not refute his earlier judgement of their aesthetic value, but rather pointed out that they were enticing for children to climb on.

26. LADBS Files.

27. Approximately 40 people attended the organizational meeting of CSRTW on April 6, 1959 at the Hollyhock House, with additional "absentee" supporters. During periods of controversy, membership has swelled into the hundreds, but reliance on voluntary support has limited the depth of involvement over time.

28. See statement by C.M. Wilson, November 12, 1959, pp. 1-9 (LADBS).

29. Ibid., p. 1.

30. The decision to conduct a structural test evoked outcries from numerous supporters of the Towers who felt that the risk was unnecessary. It also stimulated a dialogue about the role Los Angeles should have in preserving its historically significant structures. (Correspondence from Kenneth Reiner, October 2, 1959 and October 26, 1959 and Kate Steinitz, November 6, 1959.)

31. See Art News, April 1979, p. 74.

32. According to Manley, (Memo May 30, 1959, LADBS), similar action had been suggested earlier: "Sometime in 1949 or 1950, I understand the Governor of the State of California proposed that they be made a state monument. Sam, at this time, had a letter from the Governor expressing this desire."

33. See comments by Noah Purifoy, then Director of the Watts Towers Art Center, "The Watts Towers Withstood Another Test," November 1965.

34. Agreement conveyance #85246, October 24, 1975.

35. For additional discussion of repair activity, consult the section on Repair and Restoration.

36. Refer to CSRTW's "Statement on the Conservation and Preservation of Simon Rodia's Towers in Watts," May 5, 1978.

37. See California State Department of Parks and Recreation, "Construction and Maintenance Plan," May 4, 1979.

38. O.R. Bussard, Inspector. Statement on Watts Towers, June 23, 1959. File X46474, LADBS, p. 1.

39. C.M. Wilson, Memorandum of Hearing Re: 1765-69 East 107th St. (Watts Towers), Nov. 12, 1959. File X46474, LADPBS.

40. Bussard, p. 3.

41. Wilson, p. 8.

42. Resolution-Order to Repair. Board of Building & Safety Commissioners, Dec. 17, 1979, LADPS File No. X46474, pp. 2-3.

43. V.K. Lilla, Office Memo to W.C. Pearson, Sept. 25, 1959. LADBS File No.. X46474.

44. Mr. Johnson, "Notice to Comply #B72670, Sept. 2, 1960, LADBS File X46474.

45. Memorandum Aug. 28, 1962, LADBS File No. X46474.

46. Tom Wills, A Report to the Watts Towers Committee Upon Completion of Spring 1967 Repairs, Aug. 3, 1967.

47. Committee for Simon Rodia's Towers in Watts, Towers Restoration Crisis: Chronology, November 1978.

48. N.J. Goldstone "Statements ...on the Condition of the Towers of Simon Rodia in Watts," April 15, 1978.

49. CSRTW, Towers Restoration Crisis, p. 3.

50. Office of the State Architect, Conservation Maintenance Plan, May 4, 1979, p. 2.

51. Office of the State Architect Daily Construction Log, December 24, 1979.

52. Ibid, March 12, 1980.

53. Ibid, August 6, 1980.

54. Ibid, Aug. 13, Aug. 18, Aug. 19, and Aug. 20, 1981.

55. Ibid, Sept. 1, Sept. 15 and October 6, 1981.

F. RECOMMENDATIONS FOR FURTHER RESEARCH

There are two principal areas of focus for additional documentation related to Watts Towers. The first is organizing existing materials, the second, researching primary resources.

The initial step in organizing the existing materials has already been taken, i.e., transferring the CSRTW archives from private hands to the CSRTW offices. To ensure that this valuable material is preserved and utilized to its fullest potential, the following should be considered:

a. Location - Though locating the archival materials at the Towers seems appropriate philosophically, such a move would greatly impair security and public access. Depositing the records in a library or museum would provide maximum security, access, and professional curatorial assistance, as well as reflecting the public character of the monuments. Keeping the archives in the CSRTW office could be a possible compromise, provided that accessibility and proper care of the collections is ensured.

b. Organization - Development of a logical filing system and catalogue for the CSRTW collection is imperative. Each item should be registered individually using a system which enables materials to be cross-referenced by subject, date, author, and in the case of photographs, location. Where possible, location designations and nomenclature should correspond to the system developed by OSA staff. It is also suggested that the quality of the information be appraised, i.e., primary source, secondary source, local color, context, repairs, and restoration, etc. Ideally, catalogue entries should be computerized to allow greatest research flexibility, but if equipment is not available, card files will suffice. Detailed information on cataloguing procedures may be found in Ralph H. Lewis, Manual for Museums, (Washington, D.C. National Park Service, 1976).

c. Supplementary Data - Much valuable material related to the Towers remains in the collection of Committee members or other organizations. Efforts should be made to obtain copies of all documentation, including the following:

- Seymour Rosen - photographs
- Jeanne Morgan
- Brad Byer
- N.J. Goldstone
- City of Los Angeles, Department of Building & Safety files
- Los Angeles Times - clippings files

If these people will not allow copies to be made, the type and extent of information should be included in a directory of sources.

Research into primary sources is vital in order to separate the true facts from the myriad of myths that surround Simon Rodia and his Towers. This work may be undertaken by volunteers from CSRTW or by students at local colleges and universities. Whenever a scholar uses the archives, the CSRTW or organization holding them should arrange to obtain a copy of the

finished paper. The following areas for investigation are most critical:

- Birth Records c. 1872-1893 (difficult to initiate without definite information on Rodia's birthplace).
- Immigration Records c. 1890-1900 (may contain information on place of origin and age).
- Military Service c. 1917-18.
- Marriage License, Children's Birth Certificates (Northern California c. 1900-1915).
- Employment Records (Spring Construction Co., El Cerrito c. 19090-1910; Markwell Building Co., Long Beach, CA, 1912).
- Building Permits (Los Angeles, Sacramento c. 1921-23).

The following list includes persons whose association with Rodia, the Towers, and/or CSRTW can provide valuable information. Persons with astericks by their names were those contacted during the course of this study. We gratefully acknowledge their assistance and cooperation.

Relatives:

Sons:

Alfred Rodia,
Frank Rodia

Nieces/Nephews:

Angelina Alexander (Lake Tahoe)
Asunda Barrett
Brad Byer (West L.A.)*
Mary Lou Byer
Dominic Calicura (Martinez)
William Calicura
Antoinette Douvres
Alice Frank
Edith Giraldi
Genevieve Harvey
Virginia Sullivan (Martinez)

CSRTW: (includes some former and current members)

Mae Babitz (Hollywood)*
Ilse Berg - daughter of Kate Steinitz
Bill Billiter
Bruce Boehner
William Cartwright*
Jill Dolan*
Ed Farrell*
Christy Johnson*

Herb Kahn (Santa Cruz)*
Nicholas King (San Francisco)
Joan Kirkiby*
Annette LaPorte
Jack Levine
Steve McAvoy*
Jeanne Morgan*
Seymour Rosen*
Raymond St. Francis*

Local and State Representatives

Steade Craigo (California Department of Parks & Recreation)*
Mason Dooley (LA Planning Department: Photos)*
Warren Hageman (LA Department of Building & Safety: Files)
Harold Manley (now retired)
Paul J. McCarty (Board of Public Works)*
Kenneth Ross (now retired)*
Forrest Scott (Cultural Affairs, now retired)*
John Shadle (LA Department of Building & Safety: 1959 photos)*
Ward Treadwell (California OSA at site)*
Ileana Welch (LA Cultural Heritage Board)

Other Significant Persons

Zdravko Barov (J. Paul Getty Museum)
Creative Film Society (Keeper of Hale Film)
William Firschein*
Claire Biane Frith
R. Buckminster Fuller
Norman J. Goldstone*
Arloa Goldstone*
William Hale
William Jackson (photographs)*
Lucille Krasne
John Twilley*
Ralph St. A. Vaughn
William Walker
Harriet Watson

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H. HISTORICAL APPENDICES

CHRONOLOGY OF WATTS TOWERS

Date	Event	Note
c. 1872-1893	Birth of Simon Rodia	Actual date of birth is unknown.
1879-1912	Ferninand Cheval builds his Dream Palace in Hauterives, France.	The similarities between these two are frequently noted.
1900's	Rodia lives and works in Northern California.	Records of Rodia's whereabouts and employment during this period are scant. One possible employer was Spring Construction Company in the El Cerrito stone quarries.
1900's	Rodia moves to Southern California.	
c. 1912	Rodia constructs a merry-go-round and decorated wall at his Long Beach residence. (now demolished)	Rodia may have built this and other creations prior to the Towers.
19 June 1920	Letter of reference notes Rodia's employment with Markwell Building Company noting him to be "honest, energetic and capable."	This is one of the documents found attesting to Rodia's employment. during this time.
c. 1920's	Rodia settles in Watts, California and begins building the Towers.	Actual start of construction has not been determined. It is assumed by most to be 1921, as incised in the Towers. Built over three decades, the Towers form a catalogue of Americana/Southern California from the 1920s-1940s.

Date	Event	Note
29 May 1926	Watts is annexed to the City of Los Angeles.	This explains why L.A. had no record of a building permit, as Rodia had already begun building.
14 April 1932	Letter of recommendation provided by Charles F. Plummer, an architect in Los Angeles, notes Rodia's handling of plain and reinforced concrete to entire satisfaction.	This provides some indication that Rodia worked with materials he used on the Towers.
1933	6.3 Long Beach earthquake	It was of note that this earthquake cracked the foundation of the L.A. City Hall without significant damage to the Towers.
1937	Owens and Seewerker write about Sam and the Towers in their L.A. Times column "Nuestro Pueblo."	This marks the first of a series of articles exploiting the colorful nature of the Towers.
1940's	Building and Safety monitors Rodia's construction activity.	No serious deterioration is evident until 1957.
1948-1971	Clarence Schmidt builds covered homes, in Woodstock, N.Y,.	Schmidt is a contemporary "primitive" compared to Rodia.
1949-1964	Fred Smith constructs Concrete Park, Phillips, Wisconsin.	Smith is a contemporary "primitive" compared to Rodia.
1951	Jules Langsner, an art critic, takes note of the Towers.	This represents some recongition of the Towers as an artwork, not a curiosity.

Date	Event	Note
1952	William Hale highlights Simon and the Towers in a documentary for USC.	This 20 minute film made the Towers visually accessible to many people before Watts itself was by Freeway. It contains rare footage of Rodia, in action and in dialogue.
1953	Jessie Howard begins painting message signs.	Howard is a contemporary "primitive" compared to Rodia.
c. 1950's	Grandma Prisby creates the Bottle Village.	Prisby is a contemporary "primitive" compared to Rodia.
1954	Rodia stops work, repair, and maintenance of the Towers. He deeds them to Louis Sauceda and departs for Northern California.	
1954-1959	The Towers are left unattended.	Without Rodia paying close attention to the Towers, they began to deteriorate.
1955	Rodia's house is damaged in fire, cause unknown.	Vandalism was, and continues to be, a source of deterioration.
5 February 1957	Building and Safety Inspector Overlin posts danger signs at the Towers.	This marks the first government action against the Towers.

Date	Event	Note
5 March 1957	Demolition Order is issued.	
Spring 1957	Sauceda sells Towers to Joseph Montoya	
11 July 1957	Montoya has building demolished but does not proceed with plans to develop the Towers.	
1958	Continuing deterioration is noted by Building & Safety inspectors.	
1959	Building and Safety inspectors detail cracking in the Towers.	Building and Safety prepared detailed documents to support the City's claim to demolish the Towers.
March 1959	Montoya sells Towers to Cartwight and King.	Transfer to these new owners marked the first attempt to preserve the Towers for their cultural significance.
March 1959	Manley reinitiates the condemnation proceedings.	
6 April 1959	The Committee for Simon Rodia's Towers in Watts (CSRTW) holds its organizational meeting.	The forming of this volunteer-based group was and continues to be instrumental in safeguarding the Towers.
6-23 July, 1959	Hearings by the L.A. Dept. of Public Works (now Bldg. and Safety) are conducted concerning demolition of the Towers.	

Date	Event	Note
10 October, 1959	Lateral loading test is performed on the tallest Tower to determine its structural stability and safety.	The test determined the Towers sound. Settlement required that all Towers be repaired to eliminate danger.
1959-1975	CSRTW oversees activities at the Towers, including site seeing, occasional repair, and waterproofing.	The publicity of the test gave the Towers a new level of noterity, increasing visits by tourists, notables, and persons using them as a backdrop for a variety of topics.
2 September 1960	Notice to Comply issued to CSRTW to remove all patchwork done with interior grade plaster and execute all repairs in portland cement.	Documentation of past repair activity is limited.
1960	Buckminster Fuller visits the Towers and notes Rodia's early use of "reinforced concrete."	In addition to their artistic significance, persons took note of their engineering characteristics.
1961	CSRTW organizes free art classes at the Towers, drawing on their inspiration.	The success of this led to construction of the Watts Towers Arts Center.
1962	Cultural Heritage Board is created in L.A.	
1 March 1963	The Towers are declared a historic monument and are listed on the National Register for Historic Places.	

Date	Event	Note
16 July 1965	Rodia dies in Martinez, California.	
1965	Tom Wills carries out some repair, filling cracks and rewrapping a few joints.	
August 1965	Outbreak of riots in Watts, California.	These riots, which resulted in serious damage to neighboring structures did not touch the Towers.
24 Oct 1975	CSRTW donates the Towers to the City of L.A. The The City promises $10,000 for repair, through the Dept. of Public Works (DPW) DPW does not perform repair.	As part of the agreement, L.A. was to repair and maintain the Towers. CSRTW retained advisory status.
April 1977	LA Municipal Art Department receives "Watts Towers $250,000 from HUD.	DPW would not spend the funds, no work was done.
September 1977	"L.A. City Repair Specifications" are developed by City, DPW, Municipal Arts, and volunteers.	
Winter 1977-1978	Record rainfall in Los Angeles is recorded.	
March 1978	Observers express concern about condition of Towers, expressing need for emergency repair work.	
3 March 1978	City of Los Angeles closes Towers as a public liability.	

Date	Event	Note
28 April 1978	State of California awards $207,000 to L.A. for restoration work.	
May 1978	City of L.A. contracts Ralph St. A. Vaughn to perform repair work.	
19 May 1978	L.A. deeds Towers to State with 50 year leaseback.	
1 August 1978	City of Los Angeles pays Vaughn $15,200 for Preliminary Report. He begins Phase I of work.	
June-Oct. 1978	Restoration work is monitored by CSRTW and is considered unacceptable.	
4 Oct 1978	Work stoppage is ordered.	
27 Oct 1978	CSRTW files suit against City, State, and Vaughn, charging work endangers Towers status as a National Register listing.	
1979	California, under Dept. of Parks and Recreation, assumes responsibility for repair and restoration, using remainder of $207,000.	
May 1979	California Department of Parks and Recreation develop the "Conservation and Maintenance Plan." State begins emergency repair work following these guidelines.	

Date	Event	Note
Dec 1979 -Jan 1980	Patching materials applied for tension and compression tests at Smith Emery Labs.	
24 July 1980	State grant repair funds of $207,000 almost exhausted.	
20 August 1980	AB990 dedicates financial assistance to support Towers restoration.	
August 1981	Twilley and Goldstone initiate tests on joint sealants and waterproofing materials.	
12 October 1981	The Ehrenkrantz Group is selected to develop a preservation plan for the Watts Towers.	

CITY OF LOS ANGELES
CALIFORNIA

X46472

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CONSERVATION BUREAU
ROOM 338, CITY HALL
LOS ANGELES 12
MADISON 4-7221

November 12, 1959

Honorable Board of Building
and Safety Commissioners
Room 212, City Hall
Los Angeles 12, California

RE: 1765-69 East 107th Street
(Watts Towers)
Board File #59.901.14

OWNERS: Sam Rodia
c/o Postmaster
Martinez, California

Tilton Cartwright
19435 Hemmingway Street
Reseda, California

Nicholas King
870 Larrabee Street
Los Angeles 46, California

SUBJECT:

After notice of hearing posted and served, hearings pursuant to Chapter 9 of the Los Angeles Municipal Code were held on the structures at the above address on July 6, 1959, through July 23, 1959, and concluded with a final session on October 19, 1959. These hearings were held before the undersigned, C. M. Wilson, Hearing Examiner, duly appointed by the Board of Building and Safety Commissioners.

The Department of Building and Safety was represented by W. E. Wilder, Deputy City Attorney; Attorney Jack Levine represented the owners of the property. Various building inspectors and structural engineers testified for the Department of Building and Safety. Several structural engineers, a laboratory technician, and one of the property owners appeared for the owners. A total of sixty-three exhibits were received including photographs, maps, plans, reports, calculations, and affidavits. A phonographic transcription was made of the proceedings resulting in a record of some 1,263 pages. A copy of the record is on file in the office of the Board.

The structures in question are three conical-shaped, open-frame towers ranging in height from 56 ft. to 100 ft., and a dome-shaped tower topped by a spire with a total height of 40 ft. Four other similar but smaller structures that exist on the same property

- 1 -

were not under consideration. The property on which the structures are located is a triangular-shaped lot slightly greater than 4500 square feet in area fronting on 107th Street, bounded at the rear by the Pacific Electric Railway tracks and bounded on the remaining side by private residential property. A small dwelling that had previously existed on the subject property had been destroyed by fire at sometime prior to the proceedings. At the time of the hearings, no structures existed on the premises other than the afore mentioned towers and a fence surrounding the property.

These towers, consisting of numerous vertical and horizontal members, are ornamental in character and are generally constructed of various metal elements such as steel shapes, reinforcing steel, steel pipe, wire lath, metal lath, hardware cloth, sheet metal, flat steel bars, electrical conduit, furring channels, etc. These metal elements are covered with cement mortar applied in a manner similar to the application of plaster and decorated with shells, bottles, ceramic tile, broken bits of glass, pottery, tile, and various other such materials embedded in the surface.

It was set forth in the Notice of Hearing that the Board had determined from the report of the building inspectors that there was probable cause to believe the structures dangerous within the terms of Article 6, Chapter 9 of the Los Angeles Municipal Code. The Building Inspector's report attached as a part of the Notice of Hearing described the height and general structural features of the towers and observed that the property had apparently been abandoned and left open to access by children or unauthorized persons for several years, resulting in vandalism. On numerous occasions children had been observed climbing on the structures at heights ranging from 40 ft. to 70 ft. above the concrete-paved yard below, the report stated. It was charged that on many members the plaster covering had peeled or cracked, allowing the reinforcing metal to rust; and that deterioration had been observed to accelerate rapidly in the past two years. Lack of proper construction procedures, design, and materials were pointed out. It was noted that the proximity of the structures to the public sidewalk and to nearby dwellings created a hazard in the event of collapse of the structures. The following charges in terms of the Ordinance were specified.

a. That the stresses in the materials, members or portions of the towers, due to all dead and live loads, exceed one and one-half times the working stresses allowed by Article 1, Chapter 9 of the Los Angeles Municipal Code.

b. That the towers, portions of the towers or members are likely to fail, or to become dislodged, or to collapse and thereby injure persons on property.

c. That these towers or portions thereof are not of sufficient stability or are not so anchored, attached or fastened in place so as to be capable of resisting a wind load of 1½ times that specified in Article 1, Chapter 9 of the Los Angeles Municipal Code, without exceeding the working stresses permitted in Article 1, Chapter 9 of the Los Angeles Municipal Code.

d. That these towers have, because of deterioration, materially less resistance to earthquake than a new structure erected in accordance with the provisions of Article 1, Chapter 9 of the Los Angeles Municipal Code.

e. That these towers because of decay, deterioration or faulty construction are likely to partially or completely collapse.

f. That these towers have because of neglect and because of their inherent nature are and have become an attractive nuisance to children who might play therein or thereon.

g. That these towers have deteriorated and were constructed so that the supporting members or parts have less than 66% of the strength required for members of a new structure of like height.

In addition, it was alleged that the structures could not be reasonably repaired so that they would no longer be dangerous.

The owner's contention that the structures are not subject to the jurisdiction of the Department of Building and Safety, and specifically that Ordinance No. 100,677 does not apply to subject structures was rejected.

EXAMINER'S DISCUSSION OF THE EVIDENCE:

It appears that as early as 1946 members of the Building Department were aware of the existence of the towers. At that time their construction had evidently been completed and the builder, who lived on the premises and had apparently built the structures single-handed, was engaged only in repairs and perhaps some minor alterations. For the ensuing ten-year period, the Department showed no great concern over the structures. Various Department members visited the site occasionally and generally regarded the entire project with little more than a mildly amused interest. During this time the builder apparently resided on the premises and kept up a constant program of maintenance and repair.

The record is not entirely clear as to just when this set of circumstances changed but it appears that sometime prior to 1957 the builder moved away, leaving the premises unattended. In 1956 or 1957 the small dwelling burned almost to the ground. About that time a group of building inspectors engaged in housing rehabilitation work in the vicinity began to show greater concern over the property. On their occasional visits to the site, they noted that the property was no longer under surveillance, that it was not barricaded against ingress and that children were playing in and about the premises. It was testified that children were seen climbing high up on the structures, and photographs were admitted in evidence confirming this. In addition, acts of vandalism were being committed against the structures. At least one complaint was received from a neighboring property owner that objects being thrown at the towers by vandals were landing on his property. It was also noted, that deterioration of the structures themselves from lack of maintenance as well as from actual vandalism was accelerating. Apparently the property was virtually abandoned from sometime prior to 1957 to the time the present owners acquired it in May of this year.

In support of their allegation of serious deterioration in the structures, the Department prepared a report, Exhibit 24, listing all cracks and spalls of consequence in the lower levels of the towers. The recorded cracks vary from 1/16" to 1/2" in width, and from a few inches to fifteen feet in length. Spalls were recorded measuring from a few square inches in area to several inches in width and several feet in length. In addition to the hundreds of cracks and spalls, several completely sheared off members were reported. It was estimated that cracks and spalls in the upper area of the structures were as numerous or more so as those in the lower regions. No attempt was made to record the hundreds of hairline cracks also present. Cracks that were large enough to expose reinforcing materials to view showed heavy rust on some reinforcing material and a few cases where the reinforcing material was almost disintegrated or was so distorted by heavy rust that its nature and dimension could not be ascertained. Other cracked members showed rust stains on the surface of the member. Some members were cracked completely through, so that daylight was visible from the other side, and the cement plaster was loose enough that the crack could be opened up with the fingers.

It was explained that cracking of the cement plaster exposes the metal reinforcing to the action of the elements, causing oxidation or rust. If rust becomes heavy enough to expand the size of the reinforcing appreciably, the bond between the reinforcing and the plaster covering is broken causing the crack to widen and reducing the effectiveness of the member. Spalling of the cement mortar occurs when a section separates completely from the member and becomes dislodged. This action usually leaves the reinforcing

completely exposed in the area of the spall. It was indicated that effective repair would require the exposure and cleaning of a great deal of the metal reinforcing elements.

An architect and structural engineer testifying for the owner viewed the presence of rust with less alarm than the Department witnesses, and indicated that cracked members could be repaired by a simple process of grouting the crack in most cases. His testimony did not reflect on the evidence brought out by the Department as to the number or extensiveness of cracks and spalls, but only as to the effect and remedy. He stated that horizontal members were generally more deteriorated than the vertical ones; that there were some members in need of immediate replacement; and that one horizontal member might collapse at any time. Recommendations for repair of the structures including grouting of cracks, replacing of members, and sealing of surfaces were made by this witness.

Much evidence was given regarding the construction materials used, the uses to which they were put, and the manner in which they were put together. There is no doubt that in these respects the structures are completely unique and unorthodox. For instance, many of the materials used are considered suitable building materials, but not in the manner in which they were employed in these structures. Structural steel shapes such as angles and "T" bars were used as reinforcing steel in members too small to be considered columns and were not lapped sufficiently for reinforcing steel. Where reinforcing steel was used, laps were not sufficient in length and were wired tightly together, contrary to accepted practice. Furring channels were used for reinforcing, a new use for such materials. Although there was some degree of consistency in the materials used in some of the main vertical members, as a whole the structures appear to have been formed from scrap materials or whatever happened to be available at the time it was needed.

One of the chief concerns of the structural engineers were the joints or connections, of which there were hundreds in each tower. Those exposed revealed that they were formed simply by lapping the structural steel shapes past each other, binding with wire, wrapping with metal lath, wire lath, or hardware cloth, and plastering with cement plaster. According to the engineer witnesses, the only acceptable method of making such connections is by riveting, bolting, or welding. The type of joints used on the towers are prone to deterioration by their very nature, one engineer commented. All engineers seemed to agree that the structural value of such connections was an unknown quantity.

In attempting to prove the safety or lack thereof of the towers, three separate structural analyses by three separate engineers were submitted. In each case it was necessary to make certain basic assumptions in order to arrive at a rational analysis. One assumption common to all three was that all structural members are properly

connected to transmit loads and stresses. Other assumptions not common to all three must of necessity have been made by all three in order to arrive at a rational analysis. Examples of these are the assumptions that all towers are properly anchored at the base in order to prevent overturning, and that all members are of uniform cross section between connections. A comparison of the three sets of assumptions leads to the conclusion that possibly many more assumptions than those indicated were actually made by all three engineers. The conclusion is, of course, inescapable that an analyis is of no more value than the truth of the assumptions necessary for its production.

Generally, on the basis of his own analysis, each engineer agreed that there is no live load on the towers. Each agreed that the four towers under consideration are safe for dead loads in that they are not more than one and one half times overstressed. On the question of safety from the standpoint of wind and earthquake load, the agreement ended. However, it is unnecessary to go into the various conclusions on these points as other modifying and controlling elements arose.

For instance, after the Department engineers had completed their testimony relative to their conclusions, the owner's evidence showed that larger structural steel members existed in the vertical legs of the towers than had been known to the Department engineers at the time they made their calculations. This came after these same engineers had had to make a slight adjustment of their figures and conclusions upon discovery that the tower heights on which they had based their figures were in some instances inaccurate.

After the Department had completed their case and two witnesses had testified for the owners regarding some of the materials composing the towers, an agreement was entered into between the Department and the owners whereby an actual load test would be applied to one of the towers and that the results would be determinative of the structural safety of all four towers under consideration. The load agreed upon was 10,000 pounds at a height to produce 330,000 ft. lbs. of moment at the base. This load was to be held for five minutes. It was further agreed that before the load was to be applied, cracks and spalls on the tower to be tested were to be repaired and allowed to cure properly. If the tower successfully withstood the load, the Department agreed to drop all charges except those having to do with maintenance and repair.

A continuance and an extension thereof amounting to almost three months was granted for the purpose of making preparation for the test and for the test itself. After the completion of the test, the hearing was resumed. Witnesses to the test testified that the agreed load had been applied, that the tower had performed very

satisfactorily, but that the full 10,000 pound load was held for somewhat less than 90 seconds instead of the agreed upon five minutes because of the failure of part of the testing apparatus. A Department representative testified that he had observed the test design and was satisfied that it was in accordance with good engineering practice. He testified that he was also present at the time of the test and that in his opinion the tested tower would probably have withstood the load for the full five minutes had the testing apparatus not failed. He further stated that in his opinion if similar tests had been performed on the other towers, the results would have been the same.

A few of the issues set forth in the Building Inspector's report, Exhibit 3, require brief comment in order that the findings be clearly understood. The stipulation between the owners and the Department based on the outcome of the test is not necessarily binding on the Board or Examiner, however, insofar as the test has become evidence, it is as binding in this respect as any other evidence. The results of the test, although having the effect of settling the issues regarding the structural safety with respect to dead and live loads, wind loads, and earthquake loads, should be viewed with caution for this reason. The 10,000 pound load represented what both parties agreed to be the "Code" load, or the loads for which the Building Code would require the structure to be designed. The Code anticipates that structures should actually be capable of withstanding loads from two to three times those designed for prior to complete collapse. This is the safety factor or margin of safety built into the provisions of the Code. A test that employs loads no greater than "Code" loads gives no indication as to how much of a margin of safety is present, if any. A structure which the Code requires to be designed for stresses of 10,000 pounds should not ultimately fail under stresses of less than about 30,000 pounds. This would represent a three to one margin of safety.

Another significant factor regarding the test is that cracks and spalls in the portions of the tower to be affected by the test were repaired prior to the test--at least the assumption is made that they were, since that was one of the conditions of the agreement and since a continuance was granted of sufficient duration to allow for both repair and curing. If this assumption is correct, the test would be an indication of the safety of the towers after repair and not as three of them presently stand.

Although the issue of safety of the structures from complete collapse is settled, the evidence is sufficient to show that the danger envisioned in Section 96.101(a)(4) and as paraphrased in subsection (b) of page 3 of Exhibit No. 3 is present to a marked degree. These towers are of great height, are immediately adjacent to a public way, are accessible for persons either private or public to walk under or about them. There is evidence of a great deal of cement plaster having spalled off in the past. There is

evidence that whole members have become dislodged, and that at least one such member is presently about to fall. The same view is taken of this as would be taken of a building fronting on a public sidewalk where the building has loose masonry or tile veneer on the front, or gargoyles, statues, coping, or other ornamentations that could become dislodged.

Subsection (f) of page 3 of Exhibit 3 charges that because of neglect and because of their inherent nature, the towers are and have become an attractive nuisance to children who might play therein or thereon. The evidence shows that from sometime prior to 1957 up until the time the present owners acquired the property in May of this year, the property was unattended and that children were seen playing about the premises and climbing in the towers. However, the view is taken that an attractive nuisance is only such at a particular time under a particular set of circumstances; that there is no such thing as an attractive nuisance per se. And even if the structures had at sometime in the past been an attractive nuisance, this fact would no longer prevail. The property is presently barricaded and attended.

FINDINGS:

1. That the subject structures are located at 1765-69 East 107th Street within the limits of the City of Los Angeles, California.

2. That the structures are subject to the jurisdiction of the Department of Building and Safety.

3. That the materials of construction as used and assembled in the structures do not conform to the usual, ordinary, or accepted methods of construction.

4. That the structures have suffered extensive damage and deterioration due to vandalism, natural deterioration, and lack of maintenance. That the rate of deterioration has accelerated in the past few years.

5. That with respect to dead and live loads, wind loads, and earthquake loads, the structures are safe and are not presently likely to partially or completely collapse.

6. That the structures are of great height; are immediately adjacent to a public way; are accessible for persons either private or public to walk under or about them. That sizeable areas of cement plaster covering

have spalled off in the past; that entire members have sheared off or become dislodged in the past. That parts of the cement plaster covering is presently loose and in danger of becoming dislodged. That certain members are presently in danger of becoming dislodged. That in this respect the structures are dangerous to persons on or about the property.

7. That the structures are presently adequately barricaded and attended and are not now an attractive nuisance to children.

8. That the structures can be reasonably repaired so that they will no longer be dangerous; that they are in need of repair; and that they should be repaired.

EXAMINER'S RECOMMENDATION:

It is therefore respectfully recommended that the Board of Building and Safety Commissioners invite the owners and the Department to submit proposals for repair of the structures suitable for adoption by Your Honorable Body as its order. Such proposal should generally incorporate the recommendations of Structural Engineer Norman L. Pederson as recorded in the transcript, and should be designed to restore the structures to a condition as nearly approaching their original condition as is practicably possible.

Respectfully submitted,

C. M. Wilson

C. M. WILSON, Hearing Examiner
BUILDING AND SAFETY COMMISSION

CMW:ja

RICHMOND 9-3411

FORM P-3 2500 6 59 LC

SMITH-EMERY COMPANY

INSPECTING AND TESTING ENGINEERS

781 EAST WASHINGTON BOULEVARD
LOS ANGELES 21, CALIFORNIA

ASSOCIATED WITH
PITTSBURGH TESTING
LABORATORY

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LABORATORY NUMBER P-329435 DATE JUNE 30, 1959

SIMON RODIA'S TOWERS COMMITTEE
C/O LARSEN ASSOCIATES
6255 VAN NUYS BOULEVARD
VAN NUYS, CALIFORNIA

ATTENTION: H.L. KAHN, A.I.A.

RE: SIMON RODIA'S TOWERS
1765 EAST 107TH STREET
LOS ANGELES, CALIFORNIA
PRINT: ON-SITE SURVEY - 6/13/59

REPORT OF TEST AND INSPECTION

IN COMPLIANCE WITH YOUR REQUEST ON THE ABOVE REFERENCED PROJECT, WHEREIN YOU ASK THAT WE EXPOSE ONE LAP ONLY OF A VERTICAL STEEL SUPPORT ON THE SOUTH SIDE OF TOWER #4, AND TO TRACE VERTICAL LEG DOWN AS FAR AS IT GOES, DETERMINE THE THICKNESS OF GROUND SLAB SURROUNDING THE BASE OF TOWER, DETERMINE THE THICKNESS OF MORTAR ON THE FIRST LEVEL OF TOWER PEDESTAL AND THE WALL. TESTS WERE REQUESTED TO DEMONSTRATE THE ULTIMATE COMPRESSIVE STRENGTH AND THE COMPOSITION OF MORTAR USED IN THE CONSTRUCTION OF THIS PROJECT. ALL WORK WAS DONE ON THE WESTERLY TOWER ON ITS SOUTH SIDE AS INSTRUCTED AND SHOWN ON PRINT SUBMITTED TO THIS OFFICE.

INSPECTION

ONE SPLICE OF VERTICAL ANGLE IRON SUPPORT WAS EXPOSED (SEE PHOTO NO. 1) ON THE WESTERLY TOWER SOUTH SIDE(IDENTIFIED FROM YOUR ON-SITE SURVEY PRINT, DATED JUNE 13, 1959 AS TOWER NO. FOUR), JUST ABOVE FIRST LEVEL OF PEDESTAL, THIS SPLICE CONSISTED OF 2"x1.5"x1/8" ANGLE IRON LAPPED SEVEN INCHES, THIS WAS THEN WRAPPED WITH EXPANDED METAL LATH AND APPROXIMATELY ONE INCH OF MORTAR

CONT'D

RICHMOND 9-3411

FORM P-2 3502 9-58 LC

SMITH-EMERY COMPANY

INSPECTING AND TESTING ENGINEERS

781 EAST WASHINGTON BOULEVARD

LOS ANGELES 21, CALIFORNIA

ASSOCIATED WITH PITTSBURGH TESTING LABORATORY

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LABORATORY NUMBER P-329435 (CONT'D) DATE JUNE 30, 1959

APPLIED THEN WRAPPED WITH ONE-HALF INCH HARDWARE CLOTH AND COVERED WITH ANOTHER LAYER OF MORTAR. TEST INDICATES THAT THE MORTAR'S ULTIMATE COMPRESSIVE STRENGTH IS IN EXCESS OF 3000 PSI FROM THE PEDESTAL UP AND THE ULTIMATE COMPRESSIVE STRENGTH OF MORTAR SURROUNDING ANGLE IRON IN PEDESTAL IS IN EXCESS OF 4000 PSI.

PHOTO NO. 2 SHOWS THE 2"x1.5"x1/8" ANGLE IRON LOCATION IN THE PEDESTAL WHICH WAS WELL COVERED WITH MORTAR AND EXTENDED DOWN INTO FOOTING (PHOTO NO. 3) WHICH GOES FOURTEEN INCHES BELOW SLAB SURROUNDING TOWER AND THE EXCAVATION UNDER FOOTING MEASURES SEVEN INCHES. THE WHITE TAPE IN THE TOP CENTER OF PHOTO NO. 3 SHOWS THE LAST POINT THAT WE WERE ABLE TO EXPOSE VERTICAL SUPPORT WITH HAND TOOLS; AS FROM THIS POINT ON, CONCRETE APPEARS TO HAVE AN ULTIMATE COMPRESSIVE STRENGTH IN EXCESS OF 9000 PSI. OUR VISUAL EXAMINATION INDICATED THAT THE VERTICAL ANGLE IRON IS THAT WHICH IS TYPICAL IN STEEL FRAME BED ASSEMBLIES, THEREFORE WE CALCULATE THAT THIS VERTICAL SUPPORT EXTENDS TO WITHIN THREE INCHES OF THE BOTTOM OF FOOTING, AND THERE IS MINOR SURFACE DETERIORATION OF THE VERTICAL STEEL SUPPORT THAT WE EXPOSED.

PHOTO NO. 4 IS THROUGH WALL SECTION BETWEEN VERTICAL SUPPORTS WHICH CONSISTED OF ONE AND THREE-FOURTHS INCHES OF MORTAR WITH

CONT'D

RICHMOND 8-3411 FORM P-3 1500 6 58 LC

SMITH-EMERY COMPANY
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LABORATORY NUMBER P-329435 (CONT'D) DATE JUNE 30, 1959

TYPICAL BRICK MASONRY CONSTRUCTION. THIS WALL SECTION WAS DETERMINED TO BE FOUR AND ONE-HALF INCHES THICK WITH EARTH FILL BEHIND IT. PHYSICAL TEST SHOWED THIS MORTAR TO BE IN EXCESS OF 9000 PSI.

SLAB ON FIRST LEVEL OF PEDESTAL APPEARS TO BE MADE OF TWO LAYERS OF MORTAR; THE FIRST LAYER IS ABOUT ONE AND ONE-HALF INCHES OF LOW GRADE TOPPED WITH FOUR INCHES OF HIGH GRADE MORTAR.

SLAB SURROUNDING THE TOWERS IS CONSTRUCTED IN TWO LAYERS, EACH ABOUT ONE INCH THICK.

COMPRESSION TEST

SOURCE OF SAMPLES - SPLICE AREA

SAMPLE NO.	1	2	3
AREA, SQ. IN.	0.56	0.70	0.63
LOAD, LBS.	1930	2150	2020
P.S.I.	3446	3071	3206

CONT'D

RICHMOND 9-5411

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LABORATORY NUMBER P-329435 (CONT'D) DATE JUNE 30, 1959

CHEMICAL TEST

SOURCE OF SAMPLE - SPLICE AREA

ACID INSOLUBLE MATTER	69.38%
ACID SOLUBLE:	
SILICA (SiO_2)	3.64%
IRON & ALUMINUM OXIDES (R_2O_3)	3.30%
CALCIUM OXIDE (C_aO)	11.87%
SULPHURIC ANHYDRIDE (SO_3)	0.31%
LOSS ON IGNITION	9.69%
UNDETERMINED	1.81%
	100.00%

CALCULATED PROPORTION OF CEMENT TO SAND, BASED ON THE ORIGINAL DRY MIX:

BY WEIGHT	1 : 4.23
BY VOLUME	1 : 4.14

NOTE: SAND ASSUMED TO BE 96 LBS./CU.FT.

RESPECTFULLY SUBMITTED,
SMITH-EMERY COMPANY

BY: D.F. Roberts
D.F. ROBERTS, CIVIL ENGINEER

RICHMOND 9-3411

FORM P-E 2700 8 58 LC

SMITH-EMERY COMPANY

INSPECTING AND TESTING ENGINEERS

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LABORATORY NUMBER P-329435 (CONT'D) DATE JUNE 30, 1959

COMPRESSION TEST

SOURCE OF SAMPLE - BASE PEDESTAL, SIDE WALL

DIAMETER, INCHES	1.75
HEIGHT, INCHES	2.20
AREA, SQUARE INCHES	2.41
MAXIMUM LOAD, POUNDS	24,600
CRUSHING STRENGTH, LBS. PER SQ. IN.	10,207
HEIGHT/DIAMETER	1.26
CORRECTION FACTOR	.941
CORRECTED CRUSHING STRENGTH, LBS. PER SQ. IN.	9604

COMPRESSION TEST

SOURCE OF SAMPLE - BASE PEDESTAL AT SUPPORTING COLUMN

DIAMETER, INCHES	1.75
HEIGHT, INCHES	3.15
AREA, SQUARE INCHES	2.41
MAXIMUM LOAD, POUNDS	11,300
CRUSHING STRENGTH, LBS. PER SQ. IN.	4,688
HEIGHT/DIAMETER	1.80
CORRECTION FACTOR	.984
CORRECTED CRUSHING STRENGTH, LBS. PER SQ. IN.	4612

RICHMOND 6-3411

FORM P-E 2900 9-58 LC

SMITH-EMERY COMPANY

INSPECTING AND TESTING ENGINEERS

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LOS ANGELES 21, CALIFORNIA

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LABORATORY NUMBER P-32935 - A

DATE JULY 3, 1959

SIMON RODIA'S TOWERS COMMITTEE
c/o LARSEN ASSOCIATES
6255 VAN NUYS BOULEVARD
VAN NUYS, CALIFORNIA

ATTENTION: H.L. KAHN, A.I.A.

RE: SIMON RODIA'S TOWERS
1765 EAST 107TH STREET
LOS ANGELES, CALIFORNIA

REPORT OF TEST

IN COMPLIANCE WITH YOUR TELEPHONE REQUEST OF JULY 3, 1959, AT WHICH TIME YOU ASKED THAT WE DETERMINE THE APPARENT WEIGHT PER CUBIC FOOT OF THE MORTAR SURROUNDING THE LAP OF VERTICAL STEEL ON THE SOUTH SIDE OF TOWER #4, WE SUBMIT THE FOLLOWING:

	Weight Per Cubic Foot
SAMPLE #1	136.0 LBS.
SAMPLE #2	129.6 LBS.
AVERAGE	132.8 LBS.

RESPECTFULLY SUBMITTED,

SMITH-EMERY COMPANY

BY: D.F. Roberts
D.F. ROBERTS, CIVIL ENGINEER

DFR/CK

A REPORT TO THE WATTS TOWER COMMITTEE UPON
COMPLETION OF SPRING 1967REPAIRS

The bulk of the work on the towers was repairing some where around 1500 cracks ranging from 16 ft to 6 in.. Both front gates where repaired so that they swing. Most of the lower areas were patched with matching colored concrete when possible. The front tree had to be removed as were two of the three trees in the back. Arrangments were made to have the remaining trees trimmed each year ($25), so that such an extreme measure will be avoided in the future.

The future of the towers is somewhat difficult to descern at this the first extensive repair of the towers. In specting the repairs of the towers made one and two years ago I found little cracking. However, the small cracking I did detect only strengthed my believe that repairs and inspection should take place EVERY YEAR. Untill a more sophisticated means

of repair amd protection is worked out you well have to plan on an annual inspection and repair much like I have just completed. The improved material will probably come out of the plastics, a complete coating is probably the best answer however, at the moment there is no product that will solve all the requirments. I have talked to Mr Andrews of the UCLA sculpture department about the possibility of finding an interested student to do the annual repair and also mention this need to a number of leaders in Watts.

There is one final point i would like to end with and that is the need for a specific person whose job would be to look after all the many demands of the towers ranging from meeting dignataries to historical data. I would hope that you would fine this individual necassary enough to pay ~~this~~ him individual
(some of the many possible projects, i think, are imortant are mention later)

Detailed description of work
The first week Mr. Khan, Mr. Goldstone and myself meet at the towers it was agreed that there was nothing serious enough to require added strength. (afew joints where completely taken apart and rewraped) Bud and Herb agreed to take readings on the towers to check for any movement. If this has not been done i think it should be ~~done~~ and record made. Also at this time Herb introduced me to an eposy water souluble concrete (THORITE) in which after trying i felt its assets justified it being used in 1. all serious areas of repair 2. lower ribing that is directly over the head of pedestrian traffic 3. where original concrete is of a poor quality. The rest of the work was filling cracks using a standard mix 3parts pre-mix sand ½ part portland just enough water so that the mix would hold its shape when squeezed in the hand. Large repairs were covered with plastic to slow the drying time.
Note: 2½ slides explaintng steps that i used.

Thank you all for allowing me the Honor to work on the S R Towers once again. Equally satisfying was to meet many of you again, and some for the first time particularly Curtis Tann who helped me often and i think is a lucky fine for you to have as Art Director. I must mention Thelma Corden who held me together with her kindness and coffee and cakes and finaly by picking up after me and sending all my forgottens to me.

Tom Wolfe

August 3, 67.

EARL V. CARLSON
SENIOR ARCHITECT
ROUGH DRAFT
11 OCT 1978

PRELIMINARY

ADDENDUM----------WATTS TOWERS PROJECT

1. Scaffolding

a. Tower scaffolding shall be designed and erected to comply with Article 3, Section 5 of the contract which clearly states:

"In performing all of the services of the preliminary phase, and all of the services of the restoration phase, Architect shall not cause loads or stresses to be placed on any fo the surfaces of the towers, low structures, braces or walls, without prior approval of the Director."

b. In addition, loads imposed on the ground supported paving within the walls shall be distributed to prevent damage to the paving. No holes shall be cut, drilled, or otherwise installed to provide for guying, bracing or other support of scaffolding.

PRELIMINARY

2. Restoration work

a. A cataloguing system approved by City and State shall be developed to identify locations of all conservation and restoration work performed. All documentation of work will be keyed to this system. The documentation will include drawings, photographs, x-rays, and written explanations as necessary to adequately describe the processes used in restoration of all areas of the towers. Photo documentation will be by 35 MM color slide photography. Two copies of all slides, drawings, written explanations, and other documentation will be submitted to the City. City will forward one copy to State for historical record.

b. All original surfaces must be protected from staining, physical damage, and/or impact from tools or equipment during the restoration process. Where it is necessary to remove a portion of the original surface to perform work on the interior of a member or part, the portion shall be removed so as to be capable of replacement. Only if the portion removed is too small for replacement and/or it is necessary to replace parts which are missing with new materials, or when it is necessary to fill fissures, will alteration of the original surface be permitted, and then only with approved materials and methods as herein specified.

c. All tile, glass, shell, and miscellaneous decorative items recovered and stored at the site shall be sorted, documented, and catalogued in accordance with the system developed in accordance with paragraph 2a when their original location in known. Those items which the original location is not known will be carefully stored separately for future replacement in original locations when those locations can be determined. To the greatest extent possible, City, utilizing such volunteer help as may be available shall attempt to find the original location of each item, and shall appropriately mark each item so that it may be reinstalled on the towers in its proper position.

d. All decorative items, currently in place, tile, glass, pottery, and shells shall be checked for adhesion to existing mortar. If found to be loose, the item shall be recemented in place using magnesium phosphate cement as formulated by Dry Mix Products Co., Roseville, CA 95678, expressly for this purpose. Mixing and application shall be in strict accordance with the manufacturer's instructions. All fractured glass will be rejoined in situ using opticon UV-57, manufactured by Opticon Chemical, P. O. Box 2445, Palos Verdes Peninsula, CA 90274. Prior to bonding glass, the surfaces shall be cleaned with a 50-50 mixture of distilled water and pure ethyl alcohol and dried while it is still wet with a low lint paper or cloth. Temperature of cement shall be at least 70to9F before opening bottle to minimize introduction of moisture. Apply cement to fracture and allow to penetrate by capillary action. Remove excess cement with swab slightly moistened with acetone.

PRELIMINARY

e. Deteriorated or missing structural members shall be replaced when it is determined that their replacement is essential to the stability of the towers. In determining whether or not a structural member should be replaced, consideration shall be given to the report prepared by Mr. N. J. Goldstone, published January 1963 which analyzed the structural integrity of the towers, and his views shall be sought as to whether the current structural integrity of the towers requires the replacement of the member. Architect and his structural engineer shall carefully consider Mr. Goldstone's views in reaching a conclusion in this matter. Whenever there is doubt as to whether or not a structural member shall be replaced the doubt shall be resolved against replacement. The design of the structural replacements shall satisfy necessary structural requirements and be designed and detailed to be harmoniously integrated with the original structure in form and appearance, but distinguishable from the original so as to not imitate the work either in its artistic appearance or its historic aspect. Drawings shall be provided for each structural replacement and documented as specified in paragraph 2a of the addendum.

f. All fissures in the tower members shall be repaired using Magnesium Phosphate concrete (Set 45) as manufactured by Dry Mix Products Co. Roseville, CA. All fissures will be cleaned with compressed air, and all oil, grease, dust, dirt, and other loose materials removed.

Bonding surfaces shall be dampened and all standing water removed before inserting set 45. Materials shall be mixed in strict accordance with manufactures instructions adding sufficient cabasil to decrease slump for application to vertical fissures. Add sufficient pigment, of type specified by manufacturer, to mix, to produce close color match to adjoining mortar surfaces. Place or force mix into repair area and tool quickly. Work well into fissure to assure good bond. Do not overwork or over trowel. All fissures to be filled to within 1/8" of adjoining surface. No fill material is to be allowed to cover adjoining original mortar or decorative elements. Stainless steel reinforcing shall be inserted into fissures during filling where practical and where directed by City and State.

g. Work shall be performed by persons adequately trained to perform the tasks assigned. A performance test witnessed by the City and State wherein each workman can demonstrate an understanding of the materials to be used. The techniques of application, and the overall objectives of the work shall be conducted on test mock-ups before workmen are assigned to restoration work on the towers.

PRELIMINARY

A-0883C

CONSERVATION AND MAINTENANCE PLAN

SIMON RODIA'S TOWERS IN WATTS

Project Goals:

The primary goal of the project is to use the finest conservation and repair techniques available to extend the life of the towers in their present form to the maximum extent possible. The limitations of funding and present condition of deterioration necessitates that priorities be established to correct structural deficiencies where they exist before proceeding to other areas of the towers, walls, and paved areas. Valuable recommendations already received from the J. Paul Getty Museum staff and others will be incorporated into the work program where feasible. The State shall continue to seek expert consultation whenever indicated by the challenge of this most difficult task. Safe public access will be restored as quickly as possible. If feasible, visual access to provide visitors the opportunity to observe the restoration work in progress will be provided.

Project Management:

The project will be carried out by direct construction forces of the Office of the State Architect; Department of General Services, State of California. Mr. Gerald Stanley will be the project manager and Mr. J. O. Turner will be the project supervisor on the site. The project architect for the Department of Parks and Recreation will be Mr. Earl Carlson. Mr. Forrest Scott will represent the Department of Municipal Arts, City of Los Angeles, as the agency responsible for operation and maintenance of the project.

The working crew will be selected by OSA from the best qualified to perform the required work tasks. Special indoctrination will be provided each worker by OSA Project Supervisor to assure that they have a clear understanding of the construction methods used by the artist and the repair and conservation techniques to be used for this project. Each worker shall demonstrate proficiency in the assigned tasks before proceeding with work on the monument. All operations will be in compliance with CAL/OSHA requirements. Operations shall be conducted in such a manner as to protect the towers from any damage that might result from conservation efforts such as any impacts or horizontal or vertical loads that could be caused by scaffolding, materials, tools, or workers. Safe storage shall be provided for chemicals and other repair materials. A daily log will be maintained of all significant activities occurring each work day. Summaries will be prepared from the daily log and a monthly status report will be distributed by the project supervisor.

Project Priorities:

The repair of the eastmost tower will proceed first beginning with the restoration of the structural continuity of the load bearing legs, rings, and lateral supports. Following these top priority tasks and while scaffolding is in place all loose parts and decoration will be resecured in place and small cracks or fissures will be filled. Work will proceed to the center tower and western tower following the same sequence as for the eastern tower. To the extent of funds available, work will then proceed to the other structures and walls comprising Rodia's monument. Regular inspections will be made each year

by the Los Angeles Department of Municipal Arts to identify newly damaged or cracked areas as part of a continuing program of maintenance after this initial program is complete.

Repair Materials and Techniques:

The repairs to be accomplished consist primarily of those intended to restore as much strength as possible to the load bearing members now in place but damaged by the expanding reinforcement and physical movement, the reinstallation of preserved members in their original locations, securing of loose decorations, and filling of cracks to retard further water penetration. Mortar strengthening, corrosion inhibition and waterproofing are further processes to be considered as part of the conservation program. Analysis of expert opinions available indicates wherever possible steel reinforcements will be welded to existing reinforcements in members where the cracks are large enough to permit the work without removing any additional original materials. Members being reinstalled at their original connection points will be welded in place, adding steel reinforcing as necessary. Crack filling and covers for reinforcement shall be done with mortar with properties as similar as possible with those of Rodia's cement mortar. All repair mortar will be colored a uniform color selected to blend unobtrusively with the original mortar colors yet easily distinguishable from the artist's work. The mortar will be tooled to a smooth texture with a slight relief where it meets the original mortar to further distinguish the repair from the original work. Where complete forms must be reshaped such as where the reinforcing must be covered at attachment points, the general form will be reshaped using earlier

photographs as evidence if available. These repairs will be colored and finished as for all other repairs, and no attempt will be made to "re-create" Rodia's work. If necessary and feasible in some locations where new internal reinforcements must be added, the artist's work may be removed, after photo documentation, carefully preserved, and reinstalled over the new internal reinforcing. If a rust inhibiting material can be introduced without altering the present or future appearance of the structures, it will be used. A laboratory testing program of candidate inhibiting materials considered promising shall continue. All repairs will be documented and photographed, with all documentation coded to the specific location and date of repair included. All documentation will be made available for future inspection and maintenance operations. Further evaluation of water repellent materials will be done before a final selection is made. Use of a corrosion inhibitor and use of a mortar strengthening agent will influence the selection of a water repellent that will be compatible with those materials if they are used.

4 May 1979

C-5182C

STRUCTURAL LOG OF THE SIMON RODIA TOWERS

BASIC REPAIR SEQUENCE

1. Examination of proposed repair in order to secure imbedments adjacent to the repair area.

   A. Tape loose imbedments in place.
   B. Anchor imbedments with approved bonder.

   PHOTO. . . . .

2. Fissure or crack is opened to permit observation of damage and estimation of the repair needed.

   A. Chisel broken cement.
   B. Compressed air clean out.

3. Rust removal from deteriorated reinforcement.

   A. Chip rust away.
   B. Sandblast metal.
   C. Apply rust inhibitor to metal.

(any special repairs, stainless steel, (STAINLESS STEEL WIRE CLOTH) mesh,) etc. would take place here in the sequence of the repair)

STAINLESS STEEL

4. Final cleaning prior to cement work.

   A. Wire brush where needed.
   B. Compressed air blow out.

1/8 x 3/4" FLAT
3/16 x 1" FLAT
1/4 x 1/4 SQ + ROUND
3/8 x 3/8 SQ + ROUND

5. Concrete bonder applied to fissures and contact surfaces. (1/8) 1 1/4 x 1 1/4 AB.

   A. A sand-cement slurry mixed with pure Acryl 60 only. 1 1/2 x 1 1/2 AN

6. Fissure filled with a "one to three" cement-sand mix with 10% water and 10% Acryl 60 bonder.

7. ~~Tool and shape mortar to hard troweled finish and then dry brush with Concrete Cure.~~ — WET TOWEL CURED

8. Small fissures are caulked. ?

9. Waterproofing consolidatant applied. ?

*NOTE — ORIGINAL FABRIC IS SAVED AND REASS. WITH 5 MIN EPOXY (from local mgr. Thrilley has checked. Mrs. yellow), EXCESS IS REMOVED WITH TILE SAW, SAW KERF IS LEFT ON BACK OF FABRIC SKINS, SKINS ARE DIPPED IN WATER — AND APPLIED USING SLURRY MIX TO WET MORTAR

EXPLANATION OF TERMS

USED IN THE STRUCTURAL REPAIR OF THE

SIMON RODIA TOWERS IN WATTS.

Exterior Column —

The outermost column on any given tower. They are numbered clockwise starting on the northern most side of the tower.

Intermediate Column —

The column inside of the exterior column but not the interior or innermost column.

Interior Column —

The column closest to the Center core.

Center Core —

The center trunk or column that runs from the bottom to the top of each tower.

Exterior Band —

Complete bands that encircle the tower connecting (in most cases) all exterior columns. They are numbered from bottom to top.

Intermediate Band —

Complete bands that encircle all (in most cases) the intermediate columns. They are numbered from bottom to top.

Interior Band —

Complete bands that encircle all (in most cases) the interior columns. They are numbered bottom to top.

Sub Band —

Bands (running horizontally) but not completing a full circle. Sometimes sub bands make up "ladder rungs."

Brace —

Any "arm" connecting two or more bands or columns together.

TERMS -2-

Loop —

Any simi-circular band (horizontal or vertical). They are identified by moving clockwise around the tower from column No. 1 (North side).

Spoke —

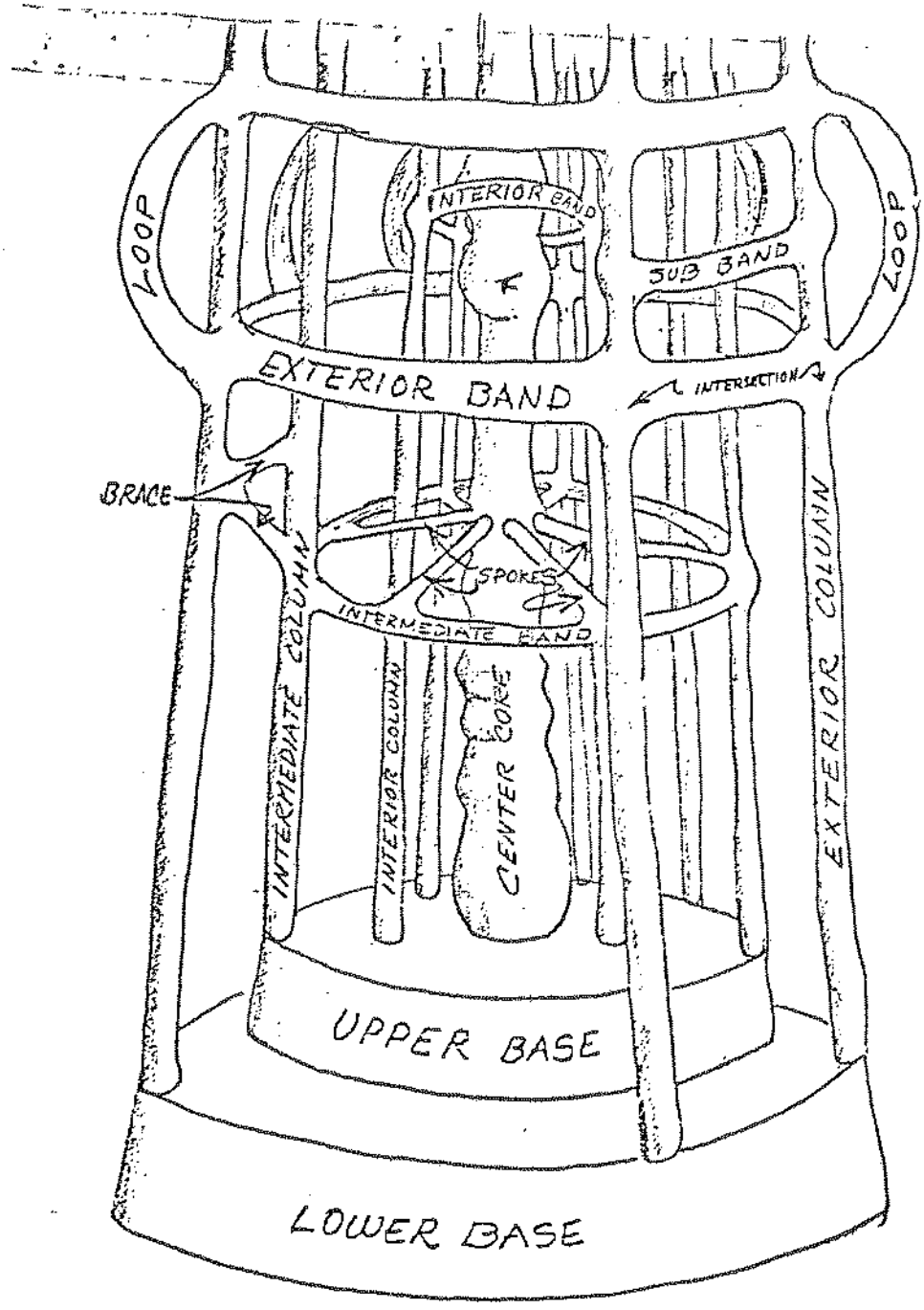
Any arm connected to the center core in a continuous manner as the spokes of a wheel coming from the hub.

Intersection —

Any area where a column meets a band or other junction of two member.

Connecting Band —

Bands connecting one tower with another tower.



TOWER PARTS IDENTIFICATION (TYPICAL)

State of California

Memorandum

To : Earl Carlson

Date : June 4, 1981

File No.:

From : Department of General Services—Office of Architecture and Construction

Subject: REPAIR EXCAVATION

To clarify my own suspicions and gain greater insight for the cracks that have appeared in our finished work, I have recently chipped back into three areas that where repaired back at the project's outset. My suspicions were partly verified but in some cases modified.

In considering any problems with our repaired work, it must be kept in mind that our present repaired work is subjected to constant deterioation and is compounded by the work process (working from the bottom up), that leaves our repairs exposed to full weathering and moisture uptake. My plan for future restoration is to concentrate on columns and leave much of the band work (intact) for the way down. Such a process is not always realistic or legistical but all efforts will be made to proceed in this manner.

Due to the nature of exterior reinforced cement sculpture and this type of homemade construction, any kind of repaired work will be difficult and experimental. The way in which funds are released, employees, commity members, and contractors have changed, and the difficulties of facilitating any job in these conditions, it is important that all persons involved take the responsibility for our present state of development. To overcome the inherent structural, legistical, material and personal problems and to build on a steeper learning, curve, greater communication and participation will be necessary.

The first area to be investigated was on the center tower. Excavation of the repair on intermediate column number one from 3' 10" to 10' 1" exposed many of the common problems of the earlier repaired work. Starting with the first step of our repair the excavation of the area was not aggressive enough to remove some of the chattered sub-layers. Sub-tile (tile that Simon Rodia covered up when reinforcing weakend member, was not removed to achieve a maximum bond. At the time that this repair was undertaken, compressed air

State of California

Memorandum

To : Earl Carlson

Date : June 4, 1981

File No.: Page 2

From : Department of General Services—Office of Architecture and Construction

Subject:

was not being used to remove dust or power sand abrasive equipment. The only kind of rust removal process was physical chipping and brushing. That is very difficult in smaller crack areas and is essential for controlling future expansion due to rusting. The first repair of this column exposed a 1½" pipe that was totally rusted through on the exposed side for about 10". In this area bars of stainless was inserted and then back filled with motar. This process was used in several of the deteriorated columns. But the pipe that was above this fill reinforcing was not left open to drain. To digress for a moment, many of the pipe reinforced columns were found full of water at thejob outset. A drain was left in our new repair just above our reinforced area.

The earlier repairs were not coated with Z.R.C. Rust Inhibitor but were coated with a less appropriate rust inhibitor. This rust inhibitor was found to be ineffective in excavated repaired areas. Existing wires are left when it is possible to retie into the wire mesh. But in most cases the wire is so brittle or deteriorated that it is impossible to tie. This leaves all of the strength of our bond dependent on physical interlocking and a successful Acryl 60 slury bond. It was thought that an Acryl 60 slury mix had an open time of 20 to 30 minutes after it was applied to a moisened surface. My past experience with this kind of patch and similar bonders illustrate that P.V.A. products will not reemulsify even when wet cement is applied. Sections where the slury mix had been allowed to loose its gloss did not bond or show any signs of reemulsifying in this repair.

At the last meeting on April 24, '81, Randy Harris Restoration Supervisor from Hearst Castle was present to add constructive suggestions. He mentioned a Hunt's product similar to Acryl 60 that would supposably reemulsifiable for up to 2 weeks and then will become fixed. After calling the Hunt's Process Lab., I was informed that this product

State of California

Memorandum

To : Earl Carlson

Date : June 4, 1981

File No.: Page 3

From : Department of General Services—Office of Architecture and Construction

Subject:

was for interior use only and never becomes fixed or non-reemulsifiable. They suggested a second coat of slury over any areas that were allowed to dry. This method has been a standard procedure since November 1, 1979.

A second repair on the east tower had been attempted in an area where Simon Rodia had used a red cement color. The red color had oxidized severely and made proper bonding impossible. Removal of this red color was achieved with physical chipping and sand blasting in only the repaired areas.

The cement mixture must be properly measured, mixed and tempered to achieve a proper bond and reduce shrinkage. John Twilley has suggested that our cracks are due to cement shrinkage. This can possibly be corrected by using minimum water and wet towel curing our scratch coats for a week before applying a finished coat. At the time when the funds were about to run out, we changed our work strategy and tried to scratch coat as much severely deteriorated areas as possible. Since our funds have been extended, these areas have been finished. Moet of these areas have shown a greater success rate than areas that were scratched coated, then finished the following day. The rough texture and bonder will not allow the surface coat to shrink away from the partially cured and pre-shrunk scratch coat or repaired edges. This technique will require future testing and John Twilley and I have started experimenting with ways to measure shrinkage of repaired areas. My belief is that some shrinkage is occuring but some columns are continuing to expand (due to unsuppressed rusting) in a clam shell fashion. I do not like to see cracks in my repairs but I am glad to sacrifice my repairs instead of original fabric. A test program to recommend a small crack filler and water proofing is still in the contract stages but will not become imperitive until we reach the winter months.

New removal techniques have been used in damaged areas. Sawing and chipping have made it possible to remove entire

State of California

Memorandum

To : Earl Carlson

Date : June 4, 1981

File No.: Page 4

From : Department of General Services—Office of Architecture and Construction

Subject:

bands, columns, etc., hollowing them out, and restoring them over stainless steel substructure. The benefits are increased repair speed and more of the original fabric to be restored. I believe further modification of this technique will develop a repair that is as impervious to exterior weathering and as stable as other experimental methods.

Yours sincerely,

Ward Treadwell

Ward Treadwell
(Restoration Specialist)

II. CONDITION SURVEY, TESTING & ANALYSIS

II. CONDITION SURVEY, TESTING, AND ANALYSIS

A. INTRODUCTION

Simon Rodia's Towers in Watts confront the preservationist with problems seldom encountered in the preservation of buildings or the conservation of works of art. The problems are born of the nature of the towers and their creator on one hand, and the limits of building science on the other. Conclusive and permanent solutions to the problems of the Towers are elusive because of their basic characteristics of structural indeterminacy, ad hoc construction and subsequent repair, and variation in materials. These characteristics inevitably threaten conclusions about repair technique based on laboratory analysis and procedures which depend on specified limits of confidence and repeatability.

Theoretically, of course, each repair could be based on detailed analysis of each instance of damage, but such a procedure would not be economic. It is therefore necesary to generalize about the nature of the damage or deterioration and about the priority and value of the repair technique. Our task is thus to develop the most plausible and risk-free generalizations with respect to safety, durability and artistic integrity.

The purpose of this introduction is to make explicit the basis upon which we intend to make our generalizations. Within the context of developing a preservation plan for the Towers, the objectives of our testing program and analysis of site conditions are as follows:

1. Verify existing original and repair materials and conditions.

2. Correlate the location of material problems with specific site conditions.

3. Support or refute hypotheses regarding structural integrity and mechanisms of deterioration.

4. Predict the effects and reliability of completed and proposed repair materials and techniques.

Any testing program carried out at the Towers must, however, recognize a number of limitations. First, no test program can cover every possible condition, particularly for such an irregular, heterogenous and complex structure as the Towers. Second, extensive tests carried out to cover the range of conditions can involve the destruction of large amounts of original material. Third, there is great danger in correlating standard tests with actual conditions and generalizing information from specific tests to the structure as a whole. Finally, a fully comprehensive battery of tests can raise more questions than they were originally designed to answer--and the end result of all work must be a viable repair and maintenance program for the Towers, not recommendations for further study.

The testing and analysis program we undertook addressed the four program objectives given above. What we sought to discover were adequate grounds for making valid generalizations about (a) the causes of problems and (b) the solutions to problems. One of the most difficult issues in developing a preservation plan is the priority to be given to the competing objectives of the actions. For the purpose of our Phase I work we suggested that goals be ranked as follows: (1) safety; (2) durability; and (3) historical or artistic integrity. The rationale for this order was that safety is a pre-condition of public accessibility as well as viability for undertaking major repair. Durability is essential to extend the life of the work, and the more that this is achieved, the greater the chance that the structure can benefit from future repair techniques not presently available. Finally, as far as possible nothing should be done to achieve safety or durability that diminishes artistic integrity, since it is the structure's value as a monument which justifies its preservation.

This approach led to an emphasis in the structural analysis on the probability of a seismic event, and consequently on repair techniques that would mitigate danger from loss of material. In analytical terms, the longer the desired life of the structure the higher the probability of a seismic event and subsequently the higher the risk of loss of material. Accordingly the repair techniques recommended in our interim Phase II report stressed replacement of Rodias mortar work around critical joints requiring repair because of prior deterioration. The aim was to achieve homogeneity of the matrix that encases the joints, thereby reducing the risk of loss of poorly re-bonded fragments of Rodia's original decorated mortar work.

Following a review meeting of these proposals (October 5, 1982), we received a clarification of design criteria from the State Department of Parks and Recreation, endorsed by a resolution of the CSRTW (Appendix 1, 2.). The new criteria set the life expectancy of the towers at 50-80 years, and sought a middle ground between the need to preserve as much of Rodia's original work as possible, and the need to minimize the life-safety hazard of the towers in the event of wind or seismic loading. It is this middle ground that is reflected in the structural analysis and repair philosophy presented in this document.

In addition to structural analysis of the towers, petrographic and chemical analyses of mortar samples were undertaken. The purposes of these analyses were to understand the consistency and composition of Rodia's original material, the degree of carbonation and chloride penetration, and to ensure that present and proposed repair materials are compatible with the original matrix. Although mortars from the towers had been analyzed previously, notably by Smith Emery in 1959, and again in 1979, there had subsequently been much speculation about the nature of Rodia's original material. The present tests provide a point of reference for future work and for the present recommendations.

B. MATERIALS

1. Existing Conditions

a. Metal Armature: The masonry elements of the Towers were generally applied to a metal armature. Vertical elements, such as the tower columns and piers on the house and walls, typically were formed of steel angles, rods, pipes or railroad ties. (Fig. 6) Less critical horizontal bands and loops were formed of smaller bars, channels or rods. (Figs. 7 and 10)

Joints were made between short pieces of steel and between horizontal and vertical members by lapping the metal elements and wrapping them with steel or copper wire. No bolts, screws or welds have been found in the original work. Wire mesh, ranging from 1/4-inch squares to 1-inch hexagons, as well as expanded metal lath, was generally wrapped around the metal, providing additional strength and facilitating adhesion of the mortar. In the case of wall areas, the lath or wire provided the primary support between vertical elements.

Condition of the metal armature is difficult to determine, as it is covered by mortar. Nonetheless, much corroded metal is readily visible through the cracked and spalled cover. It may be safely assumed that, in the majority of cases where the mortar is cracked, corrosion exists, and in fact the expansive forces associated with the corrosion contribute to the cracking. Where exposed, the metal is in fair to poor condition; many elements have been almost completely consumed by corrosion. (Figs. 6 and 7)

b. Mortar: Rodia covered the structural framework with mortars of varying composition, color and consistency. The most commonly-used material was a gray-colored sand-lime-cement mortar with a very coarse aggregate. Green, yellow, red and blue mortars can also be found, though in several cases, the color appears to have been applied as a limewash. The surface texture ranges from a relatively smooth finish, found adjacent to embedded ornament, to a stipped finish, (Fig. 19) to designs imprinted to a depth of 1/2-inch from the mortar surface. The cover depth ranges from 1/4-inch to 1 1/2-inches, with typical thickness 1/2-inch.

The mortar is in excellent condition, remaining solid and tight where it is intact. As mentioned above, however, cracks varying in length from several inches to several feet and in width from millimeters to one inch were observed throughout a majority of elements of the towers. The origin of the cracking appears to be a "chicken-and-egg" type syndrome. As indicated by the materials failure matrix (Fig. 73), there are a number of factors which could be causing the cracks, many of which are indeed present in the Towers. The issue thus becomes less one of assigning the blame than of determining what can be done.

The initial causes would appear to be two-fold: (i) open joints between various mortar types and applications due to Rodia's

failure to prepare the older material properly (Fig. 14) and (ii) movement caused by differential expansion of the members in response to heat or moisture.

The latter problem appears to have been most critical in the tall towers, particularly where they have been altered or constructed on a piecemeal basis. It is evidenced by crack patterns more complex than the vertical fissures associated with corroding metal. On the Center Tower, many of the unrepaired cracks contain pulverized fragments, indicating differential movement between the sides of the crack. (Figs. 15 and 16) Located on the intermediate and central columns, these cracks frequently occur over earlier tile and mortar layers, suggesting earlier instability which Rodia attempted to counteract and/or that they result from differential expansion between the various layers.

On the West Tower, many cracks are located above joints or laps in the steel. (Figs. 17, 18 and 20) In the case of joints between bands and columns, the initial cause of the cracking appears to have been expansion of the members in different directions upon heating by sunlight, rather than corroding steel. The rings are fixed to the structure by spokes which are tied to the rings by overlapping steel, mesh and/or wire ties to form "knuckles". Heating of the rings results in their expansion and circumferential enlargement, which results in tension at the knuckles. Temperature cycling can result in cracks which will permit the mortar encasing the steel to carbonate and water to penetrate to the steel. While initially a cyclic process, with cracks opening and closing over a 24 hour period, the cracks eventually become permanent as sand and mortar granules wedge between the edges to prevent complete closing.

Once cracking is initiated, the primary cause of fissure growth becomes corrosion. The openings allow moisture to penetrate the cover and come in direct contact with the metal. The cover has also lost the natural protective value of concrete's high pH through exposure to the atmosphere. Both factors allow corrosion of the steel to take place unchecked, and expansion of the corroded metal forces the cover to crack. This process can be seen in action throughout the Towers. (Figs. 2, 4, 6, 7)

Cracking in repair mortar represents a different set of problems. In the case of the repairs to the Gazebo made with Set 45 magnesium concrete mix, failure was caused by a combination of incompatible materials and improper preparation of the metal and original mortar substrates.

In the case of early OSA repairs, (Figs. 34 and 38) cracks are due to shrinkage caused by excess cement content, use of Acryl 60 and/or insufficient wetting of adjacent original mortar, as well as continuing corrosion in the underlying metal. The former conditions are evidenced by cracks running parallel to the joints between old and new materials (Fig. 34); the latter are indicated by cracks which continue from the old into the new mortars. (Fig. 38) Shrinkage cracks may be assumed to be inactive once the mortar has set.

Corrosion-related cracks should be monitored and, if the results indicate corrosion is continuing, should be completely cleaned out and repaired.

c. Embedments: The mortared surfaces of the various structures of the Towers are embedded with a variety of decorative elements. A comprehensive inventory of the different materials would be both impractical and of limited value. In general terms, the materials include:

- Tile: glazed and unglazed, smooth and sculptured, ranging in size from 1/2-inch squares to 3" x 6".
- Crockery: plates, cups, bowls and teapots, of varying sizes, patterns and colors, whole and fragments.
- Glass: bottles, neon tubing, mirrors and window glass, whole or fragments, colored and clear.
- Pebbles, rocks, clinker and stone veneer.
- Seashells.
- Cast stone.

The embedments are generally in good condition, though tiles and crockery in the upper levels of the towers are covered with soot. Nonetheless, they suffer from a range of problems associated with the condition of the mortar matrix.

Approximately 5% of the embedments are loose, some as a result of shrinkage of the mortar surrounding them, others because of the movement within the matrix (see below).

Approximately 5-10% of the ornament is smashed as a result of vandalism. Shells, glass sheets and large plates have been particularly vulnerable.

Another 5% of the ornament is cracked as a result of cracking in the concrete cover in which it is embedded.

d. Description and condition of individual structures. Watts Towers is an assemblage of large and small towers, decorative walls, chimneys and other freestanding elements that cover a triangular site. (See Plan Fig. 72). Because many of the material conditions are related to specific locations, the components and their conditions are described below:

FRONT AND REAR WALLS. The 10 foot high front wall, running along the south boundary of the site, contains three gates. The west gate measures approximately 7 feet wide and opens onto what appears to have been a garage; two green plastered doors are fixed in place with a bar. The center gate includes a canopy linking it to the door of the House and is flanked on the inner (south) side by mailboxes, shelves

and two planters, one containing an orange tree. The east gate is approximately the same size as the center gate, and includes a door covered with pink plaster and incised decoration.

The wall spanning the gates is divided into 6-foot-wide bays with a lower, center and arched upper panel. (Figs. 39-41) Pilasters between the panels originally ended in large finials, but now continue upward to overhead arches linked with other elements in the complex. Typically, the wall is completely covered with ornament on the outer or south side, but only the pilasters and upper panels of the inner side are decorated.

The rear wall runs along the northeast edge of the property and is composed like the south wall. The outer or north side is undecorated, while the inner side generally includes decoration on the upper and central panels only. (Fig. 51) A gate with arched door covered in glass mosaic opens from the west end of the wall; a barbeque with 15 foot high flue, cupboard and benches are built into the wall adjacent to the gate; (Fig. 50) and a planter or well is located between the West and Center Towers.

The north and south walls are generally in fair condition. Problems include the following:

-- Rusted reinforcing metal, with subsequent cracking and spalling of concrete cover. Approximately 40-50% of the reinforcement, located behind the piers and along the top and boundaries of the arched panels, are affected. (Figs. 46-48)

-- Cracking between panels of varying mortar types. (Figs. 41 and 49)

-- Cracked, loose or missing ornament. The south side of the wall, most accessible to vandals, has been most seriously affected. (Figs. 43 and 45).

-- Holes cut through walls for passage of electrical conduits.

PAVING. Inside the walls, the entire surface of the property is covered with green concrete paving, scored in large circles and squares and decorated with incised spirals and patterns.

Paving is generally in good condition, though cracks at various locations indicate settlement or earthquake damage.

HOUSE. In the northwest corner are the remains of Rodia's house, measuring 20'6" x 37'6". (Figs. 52, 55 and 58) The south wall, with a door flanked by two rectangular window openings, is entirely plastered and decorated, but consists of exposed metal lath and wood framing on the inside. Tiled steps at the center flank tiled benches along the base. The east wall consists simply of six 8" wide piers, spaced 4 to 8 feet apart and a chimney with 29 foot high stack. Piers are decorated on the outer side and connect to overhead arches. A wood floor has been constructed inside the house.

The ruins of the House are in very fragile condition:

- The inner sides of the south wall and east piers were never intended to be exposed to the weather. Since the roof and interior finishes have disappeared, metal lath and wood framing are exposed to the rain and sunlight. (Figs. 58 and 59) Subsequent swelling, corrosion and decomposition threaten the stability of the mortar and decorative elements on the outer side.

- The elements of the House were originally integral parts of a larger structure. While overhead arches tie them to other parts of the Towers, they cannot provide sufficient support to withstand wind or earthquake loading, or even careless blows by passers-by. One of the piers has already been snapped in two. (Fig. 59) The large cracks between the south wall and adjacent bench suggest that this end of the wall has fallen inward. (Fig. 53)

- There is a large hole in the back wall of the chimney, presumably created by vandals. (Fig. 56)

- The glazed tiles decorating the steps and benches have been scratched and worn by foot traffic.

GAZEBO. The Gazebo is a hemispherical construction immediately east of the House. (Figs. 60 and 61) It is 19 feet in diameter, 40 feet high and consists of a 3-foot-wide base with benches along the inner side and columns linked by horizontal bands. The columns arch at the 15 foot level to meet a tiered center core, which continues upward, stayed by loops and subbands, to a peak marked by a lead or zinc statue of a goddess.

The Gazebo suffers from problems typical of all the tower structures as well as improper repair techniques implemented in 1978.

- Reinforcement in the upper portions of the Gazebo is rusted and the concrete cover has spalled. Approximately 20% of the members are affected.

- "Set 45" replacement mortar on the columns has cracked. 12 of the 19 columns are thus affected. (Figs. 62 and 63)

SMALL TOWER NO. 1 is located south of the Gazebo and east of the House. (Fig. 70) It is 6 feet in diameter and 27 feet high. The two-foot-high base continues upwards in a bulbous inner core, flanked by four columns that intersect with the core at mid-height. The core is then surrounded by loops and subbands to the apex.

Reinforcement in 25% of the members is corroded and mortar has cracked and spalled.

SMALL TOWER NO. 2 is located directly east of Small Tower No. 1, between the Gazebo and West Tower. (Fig. 65) It is 6½ feet in diameter and approximately 15 feet high. It consists of a series of stepped circular platforms, decreasing in diameter to the top.

The tower is generally in very good condition, with cracking only in the top finials.

PINNACLES are located east of Small Tower No. 2 and directly west of the east gate. (Fig. 66) Set on an ovular, 2-foot-high base, they include six glass-covered concrete cones of varying height and a 15-foot tower. Similar in construction to the other towers, it consists of a central core, short loops and bands.

The base and concrete cones are generally in good condition. The 15 foot tower suffers from problems typical of the towers, with approximately 15% of the members cracked. (Fig. 67)

WEST TOWER is located east of the Gazebo and measures 15 feet in diameter and 99' 6" high. The base consists of four stepped circles, beginning at 4 feet high at the base and ending at 8 feet at the center core. Sixteen outer columns are anchored in the bottom ring and run upward to a height of 12 feet, where they are supplemented by a ring of interior columns. The columns are linked by horizontal bands, which in turn are joined every 2-3 bands by vertical loops (18 in all) and by cross-shaped bracing at mid-height.

Repairs on the West Tower had reached the 40 foot level in November 1982, or 30% complete,, though much minor cracking in the lower areas remains.

CENTER TOWER is located between the East and West Towers and measures 13½ feet in diameter and 96' 10" high. The base is dome-shaped, 8 feet high at the center. Eight exterior columns grow from the outer edge of the base; 8 intermediate columns stand between the outer columns and the center core. Horizontal bands are joined to the inner and outer columns approximately every one to two feet, with short bands. A series of vertical loops and heart-shaped members punctuates the construction at the 20 foot level.

Repairs had reached the 40 foot level as of November 1982, or 74% complete. Many minor cracks, as well as cracks in previous repairs, remain below. The center core and intermediate columns are subject to extensive cracking--affecting approximately 70% of the members--caused by differential expansion stresses,

EAST TOWER, located east of the Center Tower and west of the Ship, is 9 feet wide and 57 feet high. The base, 3 feet high on the outside, consists of a series of rings of decreasing diameter. The tower includes 6 outer columns and 8 inner ones as well as the central core, with columns joined by horizontal bands.

Structural stabilization repairs had reached the top by November, 1982.

Between the Center and East Towers is a slender, 50-foot-high SPIRE. It has no base, but is tied to arches linking the towers. It consists of a series of members formed in open hearts with a vertical core.

In the east corner of the site is an oval-shaped construction referred to as the SHIP. (Figs. 68, 69 and 71) The base measures approximately 15 feet along the long, east-west axis and consists of rings decreasing in diameter to a height of about 8 feet. At either end are small towers. The west one is a 12-foot-high stack of bowl-shaped castings; the east one is 30 feet high, with loops and bands about a center core as in Small Tower No. 1.

The base of the Ship is in good condition, despite damage by vandals. On the shorter west construction, metal armature is corroding, causing the cover to spall. (Fig. 70) On the taller east tower, problems typical of the other towers are present, with about 10% of the members cracked.

Linking the Walls, Gazebo and the various towers is a network of OVERHEAD ARCHES. These are constructed like the bands and columns of the towers, averaging 5 inches wide and covered with embedments.

The Arches suffer from the same problems as other elements of the towers, corrosion, cracking, spalled cover and loose decoration. Their position over main traffic paths makes their condition of particular concern.

2. Testing and Analysis

The report from Erlin Hime Associates on the following pages provides petrographic and chemical analysis data on identified samples of mortar from the towers.

In general terms the aggregate/cement ratio is quite consistent at 2 1/4-3:1, assuming that mixes were not gauged. Apart from the strength of such mixes which may have contributed to shrinkage micro cracking, the finding contradicts a frequent assumption that Rodia's mixes were highly inconsistent. Further there is no conclusive evidence in the analysis of Rodia's use of lime in his mortar, a speculation that has in the past been made to suggest high permeability of Rodia's mortar. The analysis of hardened mortar samples by ASTM C85 seeks primarily to establish cement content. Although the analysis may reveal constituents consistent with lime, these can also relate to other matter present in the aggregate. Therefore lime contents cannot be revealed with any reliability. The high compressive strengths of the mortar reported in 1979 tests done for the Office of the State Architect by Smith Emergy are inconsistent with significant lime content. Although the reported strengths should be adjusted downwards because of problems of instrumentation and sample size, strengths are still more consistent with a Type M mortar (no lime) than one containing lime. It remains a plausible speculation, though that Rodia used some lime in his mix, since that was the principal plasticizer with which he would have been familiar. He may well have kept lime content to a minimum to achieve workability, though, because

he was consciously seeking high strength in his mortar. In other words, he shared our view of the towers as a reinforced concrete structure, rather than as a mortar-ornamented metal sculpture.

The results of the anaylsis do include reference to the presence of chlorides and the use of air-entrained mortars, neither of which attributes can be explained conclusively. There are however several possibilities explaining the chlorides in the mortars: (1) the sand is actually a natural chloride-containing beach type sand; (2) the sand had been washed with brine water (e.g. sea water); (3) Rodia added a chloride salt to the mortars; (4) atomospheric chloride-borne particulates infiltrated the in-place mortars. There is no consistent relationship between chloride level and height of the structure, except that the highest values are at the lower and upper levels of the structure. Small amounts of Chloride (e.g. sodium chloride) have been reported to not be unusual additions to mortars in past years. If that was indeed the case, then Rodia built into the structure a "self-destruct" mechanism, namely corrosion.

The air-entrained mortars were found from 67th and 75th foot elevations. Because purposeful air-entrainment was not discovered until the early 1940's, the use of the air-entrained mortars (Specimens 6 and 9) must represent post 1950 construction, and they may represent late patches, or later second-layer applications using an air-entraining portland cement or air-entraining agent. The use of an air-entraining cement is more probable. And it may have been either accidental, or he found that an air-entrained mortar provided better workability, a lower water-cement ratio, and a greater "stickiness."

ERLIN, NIME ASSOCIATES, INC.

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PETROGRAPHIC AND CHEMICAL STUDIES OF MORTARS FROM THE WATTS TOWER FOR THE EHRENKRANTZ GROUP

* * * * * *

SUMMARY AND DISCUSSION

The mortars were portland-cement-based and made with similar siliceous fine aggregates (the fine aggregate does not appear to be beach sand). Portland cement was abundant in each specimen, and although hydration of the cement was normal, it was not particularly advanced in most specimens. The latter is judged to be due to generally relatively low water-cement ratio pastes, exposure in relatively dry environment, and mortar surfaces that do not retain water because of their rounded configuration.

Steel encased by the mortars in all instances was severely corroded. Contributing to the corrosion was the presence of chloride in amounts greater than the threshold level for promoting corrosion (about 0.15 percent by weight of cement), and carbonation of the mortars due to the extended exposure to atmospheric carbon dioxide. The latter process destroys the passivity imposed on steel by the originally alkaline cement paste.

Based on the analytical data, almost all of the mortars were within normal specification limits for component proportions: one part portland cement to 2¼ - 3 parts of sand. One mortar was slightly leaner, and one sligtly richer. The mortars were thus well proportioned.

Attached is a letter dated August 3, 1982 from Bernard Erlin to Andrew Rabeneck of The Ehernkrantz Group. In that letter there is provided comments on repairs and on the probable cause of some of the distress.

The distress is manifested predominantly as cracks, corrosion of steel, and spalling of mortar. Judged to be primary contributors to the crack formation are: (1) volume changes and the total absence of means to accommodate those changes - the volume changes being due primarily to thermal expansion and contraction; and (2) rusting of steel.

* * * * * *

INTRODUCTION

On July 28, 1982, B. Erlin of Erlin, Hime Associates, Inc., and P. Hawks of The Ehrenkrantz Group surveyed the Watts Towers, primarily for the purpose of obtaining a selection of specimens for laboratory studies. The specimens taken were analyzed in the laboratory for compositional and textural characteristics using methods of petrographic microscopy, X-ray diffractometry, and chemical techniques.

Specimen - Obtained during the survey were nine specimens. The location of each specimen and several other pertinent features are given in Table 1.

Petrographic Studies - Aggregate of each specimen was a similar siliceous sand-sized material that was either a crushed granite or a poorly rounded natural sand. The maximum size of the aggregate varied slightly between specimens, and contained quartz, feldspar, granite, mica, and mafic minerals.

The mortars were portland-cement based; seven of the nine specimens were non-air-entrained, and two were air-entrained. The air-entrained mortars probably represent later construction and probably are patches.

Water-cement ratios were from moderately high to very low, and generally moderate to moderately low. Residual cement particles were always very abundant, a result of the good water-cement ratios. Hydration of the cement, although not particularly advanced, was in all cases normal.

On three specimens were pigmented mortars having compositions similar to the other mortars, but also containing the pigment.

Consolidation of the mortars generally was good except in areas of contacting steel where mild to severe honeycombing flanking the steel was present. In one instance, corrosion products were present on the impression of embedded pipe.

Wires, expanded metal lath, and other metals embedded and in contact with the mortars were extensively corroded, and the corrosion had a lamellar configuration.

A summary of petrographic features are given in Table 2.

X-ray Diffraction Analyses - Each of the mortar samples was analyzed for crystalline components by techniques of X-ray diffractometry. The data are given in Table 3.

Chemical Analyses - Based on the X-ray diffraction and petrographic studies, the mortars were analyzed by methods specially chosen as most applicable to the indicated compositions:

Soluble silica was determined essentially by the chemical procedure of ASTM C85, "Cement Content of Hardened Portland Cement Concrete".

Calcium and magnesium oxides were determined by atomic absorption spectroscopy.

Insoluble residue was determined by digestion hydrochloric acid and filtration.

Losses on ignition at various temperatures were determined as a measure of -

at 110°C, free water
at 550°C, combined water
at 950°C, carbonates and carbonation.

Chloride was determined by an acid digestion, potentiometric titration procedure.

Based on the data and the studies:

Portland cement was calculated from both the silica and calcium data, the lower calculation applying in accordance with ASTM C85.

Sand was calculated by difference : 100 percent less the sum of portland cement and total water. "Sand" may include any pigments present.

The data are given in Table 3.

August 23, 1982

Erlin, Hime Associates, Inc.

William G. Hime
Vice President

Bernard Erlin, President
Petrographer

Specimens will be retained for two years and then discarded unless a notification and storage fee is received.

TABLE 1 - Location and brief discriptions of specimens from the Watts Towers.

EHA No.	Tower	Column	Elev-ation(ft)	No. Layers	Condition of Steel	Location
1	Middle	Ext.Col.2	12	1	Corroded	Intermediate band
2	West	11 to central core	17	2	Corroded	Spoke between col. and central core
3	West	14	58	1	Corroded	-
4	West	4 to 5	58	2	Corroded	Spoke between columns
5	West	3	42	2	Corroded	-
6	East	-	67	1	Corroded	Intermediate band20
7	East	Intermed-iate Col.1	25	2	Corroded	Knuckle of spoke to band
8	West	13	75	1	No steel	Band 36
9	Middle	-	72½	1	Corroded	Knuckle at band 24

TABLE 2 - Petrographic features of the specimens.

EHA No.	Apparent Water - Cement Ratio	Air, %		Specimen Thickness (in)
		Air-Entrained	Non-Air Entrained	
1	moderate	-	6-8	½
2	moderate	-	6-8	3/4
3	very low	-	10-12	3/4
4	moderately low	-	10-12	1¼
5	moderately low	-	8-10	3/4
6	very low	14-16	-	1½
7	moderately low	-	8-10	1¼
8	very low	-	6-8	3/8
9	very low	10-12	-	1½

TABLE 3 - Analytical data for the mortar samples.

Determined or Calculated	Result for Sample 1	2	3	4	5	6	7A	7B	8	9
Soluble silica, %	8.28	5.70	6.84	7.85	7.37	5.86	4.96	6.70	4.42	7.22
Calcium, oxide, %	26.07	16.43	18.80	20.23	19.90	19.63	21.32	24.75	17.45	18.70
Magnesium, oxide, %	0.72	0.82	0.72	0.87	0.90	0.52	1.13	1.45	0.90	0.67
Insoluble residue, %	45.56	60.75	59.75	50.67	53.99	55.38	52.32	46.27	60.72	58.65
Loss on ignition, % to 110°C	3.12	2.28	2.07	3.87	3.88	2.30	1.81	3.22	2.35	2.35
110° to 550°C	6.07	6.03	3.45	5.89	5.06	5.53	5.09	6.55	5.92	5.03
550° to 950°C	4.22	6.05	5.12	4.13	2.97	7.43	10.67	6.30	4.09	5.79
Chloride, %	0.16	0.06	0.05	0.12	0.05	0.09	0.06	0.04	0.06	0.09
Portland cement, % based on silica	39.43	27.14	32.55	37.38	35.09	27.90	23.64	31.93	35.36	34.38
based on calcium	41.05	25.87	29.61	31.86	31.34	30.91	33.57	38.98	27.48	29.45
Sand, %	51.38	65.82	64.87	58.38	59.72	64.27	69.46	58.30	64.25	63.17
Portland cement:sand, volumetric proportions	1:1.5	1:3.0	1:2.6	1:2.2	1:2.2	1:2.7	1:3.5	1:2.1	1:2.7	1:2.5
Chloride, % by wt.cement	0.40	0.23	0.17	0.38	0.15	0.31	0.25	0.11	0.21	0.31
Components detected by X-ray										
Quartz	M*	M	M	m	M	M	M	M	M	M
Calcite	m	M	m	m	m	M	M	M	m	m
Feldspar	M	M	M	M	M	M	M	m	M	M
Calcium hydroxide	m	–	–	m	m	t	–	m	–	–
Portland cement (unhyd.)	t	–	t	–	–	–	–	–	–	t

*M major
m minor
t trace

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C. STRUCTURAL ANALYSIS OF THE TOWERS

1. STRUCTURAL ANALYSIS CRITERIA

The purpose of the structural analysis of the towers was to review the existing structure and form opinions of the structural competency of the towers using the following criteria:

- The strnctural condition of the towers as determined by the 1959 load test has been modified by documented and visible repairs.

- The current deterioration of the tower members will be mitigated by repair techniques. These techniques will diminish annual number of required member repairs during the extended life of the towers.

- The life of the towers is extended into the future for an undetermined number of years. This extended life of the towers is such that the probability of horizontal loading of the towers by wind storm or earthquake is moderate to high.

- The intensity of wind storm that will occur within the extended life of the towers is equal to that intensity used for current design of new buildings. The referenced document selected for analysis purposes is the 1982 Edition of the Uniform Building Code. This reference states the annual probability of the design wind speeds used for analysis is 2%.

- The spectrum intensity of ground shaking in the vicinity of the towers, caused by the probable earthquake, is about one-half of the intensity utilized as design level for new structures in the Los Angeles basin. This earthquake has an estimated annual risk of about 2%.

- Preliminary studies of the structural response of the towers to the design level earthquake used for new structures in the Los Angeles basin indicate that significant damage to the historic fabric of the towers will be caused by this described event. Repair techniques proposed to minimize this probable damage requires removal of the historic fabric beyond the zones damaged by ongoing corrosion and replication of the historic surfaces rather than reinstallation of the salvaged historic fabric. Estimates of the loss of historic fabric caused by these procedures were compared with estimates of loss of historic fabric that may be caused by the design level earthquake These estimates were made for two strategies. First, that maintenance of structural integrity is of primary importance. Second, that preservation of historic fabric is of prime importance. The

described studies indicate the first strategy is not significantly effective in reducing the sum total of loss of historic fabric. This assumes the design eartquake occurs after the majority of structural repairs caused by surface cracking and corrosion of the metallic core have been completed.

2. STRUCTURAL ANALYSIS PROCEDURES

The structural analysis included the following specific subtasks:

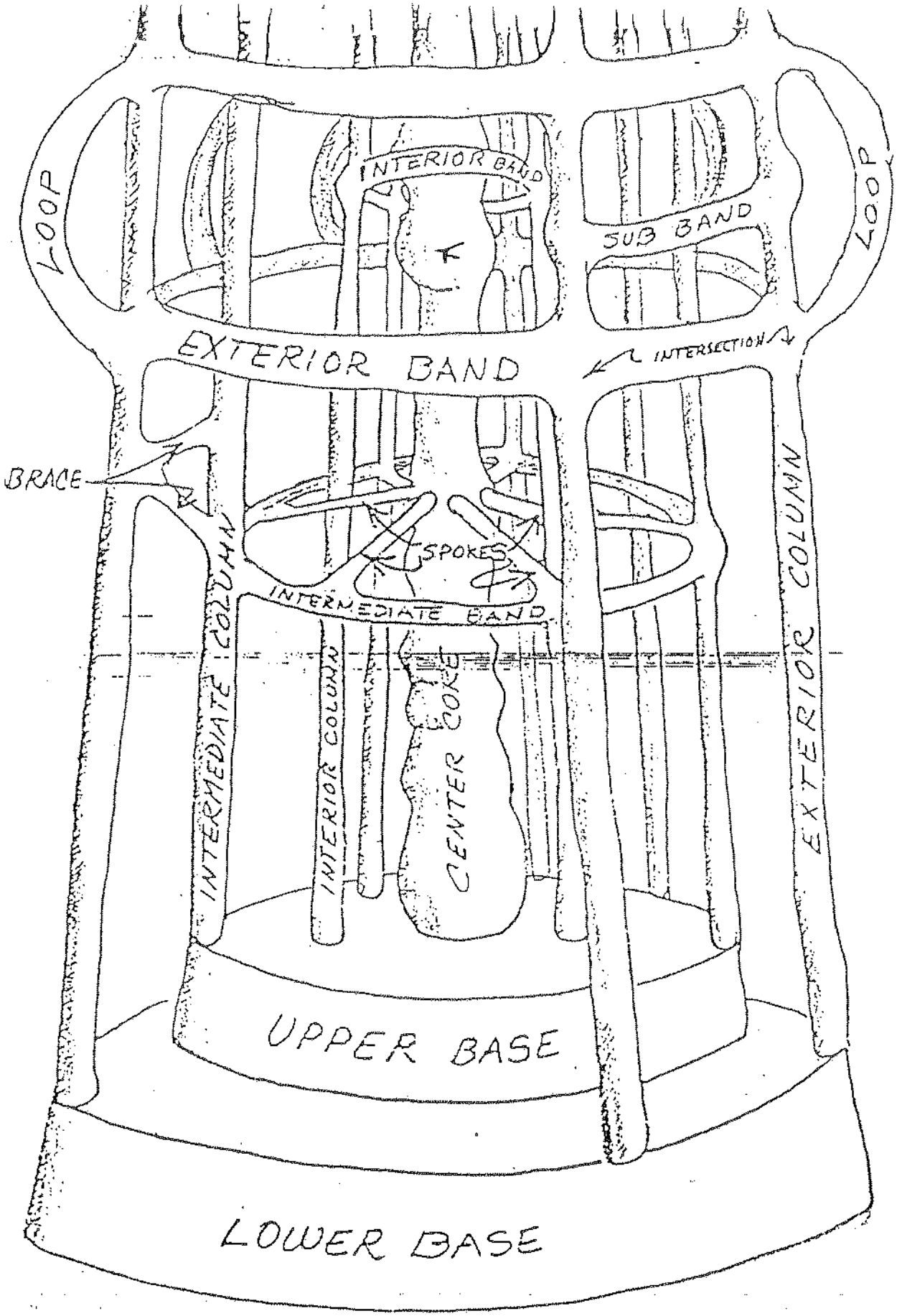
- Review Rodia's construction techniques to determine a general opinion of the variability of metallic members enclosed in the members.
- Analyze the existing structure to establish a rating of the existing members as to their comparative value in supporting the weight of the towers.
- Analyze the probable effect on the towers of design winds or probable earthquakes. Develop a rating of members as to their comparative value in resisting displacements caused by wind or earthquake loads.
- Evaluate the effects of the randomness of Rodia's techniques and the probability of an undiscovered discontinuity of any member or juncture of members.
- Develop opinions of the probability of life-safety hazards caused by design winds or probable earthquakes.
- Evaluate probability of significant loss of historic fabric due to design winds or probable earthquakes.
- Develop concepts of repair techniques that will maintain the structural capacity of the towers to withstand gravity and probable horizontal loads.

The analysis was intended to be used as a basis for a recommended repair program that would have minimum impact on the historic character of the towers and the adjoining frameworks and walls. Maintenance programs and priorities of member maintenance have been developed from the conclusions of the structural analysis.

3. DESCRIPTION OF THE STRUCTURES

The towers and the adjoining frameworks are space frames composed of vertical columns and a central core. The vertical members were joined by bands and spokes as shown in Figure 1. The vertical members extend from a base or series of bases. The bases were formed of earth and rubble fills covered by concrete.

The members of the space framework were constructed by wrapping a central steel member with lath or wire prior to application of a mortar coating. This mortar coating was built out to the final dimension and



TOWER PARTS IDENTIFICATION (TYPICAL)
Figure 1

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forms the backing for applied ornamentation as well as the completed member.

Junctures of the members were generally made by attaching the partially completed spokes or bands to the vertical leg by wire. The juncture then received a mortar coat to bond the two members into a joint with a moment and shear transfer capacity.

The towers, pergola and other structures serve as support for the walls along the property lines. The interconnecting members were constructed similarly to the described tower elements.

4. STRUCTURAL LOAD TESTS

In 1959, the west tower was loaded horizontally with 10,000 lbs. applied at a height of 33 feet above the tower base. The observed performance of the tower at the time of loading can be termed elastic, that is, no definite change in the slope of the load-deflection plot can be noted.

These tests did not establish an upper bound of elastic capacity of the towers to withstand horizontal loads. They did establish an elastic load-deflection plot that can be used for estimation of elastic structural response to earthquake motion. They also provide a known imposed loading for estimation of elastic stresses in the tower framework.

The magnitude of the applied load and the point of application closely approximates the computed design wind force and its center of force application for this tower. The estimated inertial response force caused by the probable earthquake and the resultant base moment approximates the design wind base shear and moment.

5. CAPACITY OF THE TOWERS TO WITHSTAND GRAVITY LOADS

An indication of the gravity load capacity of an historic structure is its past performance. The tower legs, braced against buckling by bands and spokes, have carried the tower weight without distress. The space frame has tolerated removal of members for repair due to corrosion of the metallic core and complete replacement of a vertical member without indicated distress.

The weight of a tower is carried by the columns and central core. The bands on the columns, loops, spokes and braces stabilize these compression members. The vertical spacing of these stabilizing members has a reasonably linear influence on the vertical load capacity of the columns, that is, if the spacing of bands is halved, the probable load capacity of the member is doubled.

The interconnection of the framework is vital to maintain structural integrity under gravity loads. The load transfer mechanism between columns, bands, spokes, etc., is lightly stressed. The interconnection methods known to have been used by Simon Rodia had a high probability of adequate performance, if corrosion had not occurred.

The gravity load-carrying system can be termed a redundant system. That is, the capacity of the system is not highly dependent on the performance or load-carrying capacity of any single member. Table 1 describes the relative importance of each tower member in resisting the gravity loads of the tower (vertical loads due to weight of the tower).

TABLE 1

CATEGORIZATION OF MEMBERS FOR GRAVITY LOADS

Columns:	Primary gravity load support--moderate stress
Center core:	Primary gravity load support--low stress
Bands on columns:	Provide bracing for stability of columns--low stress
Bands on loops:	Not part of gravity support system except for self-support
Loops:	As above
Spokes:	Provide bracing for stability of columns--low stress
Braces:	As above

6. PROBABLE HORIZONTAL LOADS IMPOSED ON THE TOWERS

The significant horizontal loadings of the towers will be due to static and dynamic effects of extreme winds and the horizontal inertial forces caused by earthquake ground motions.

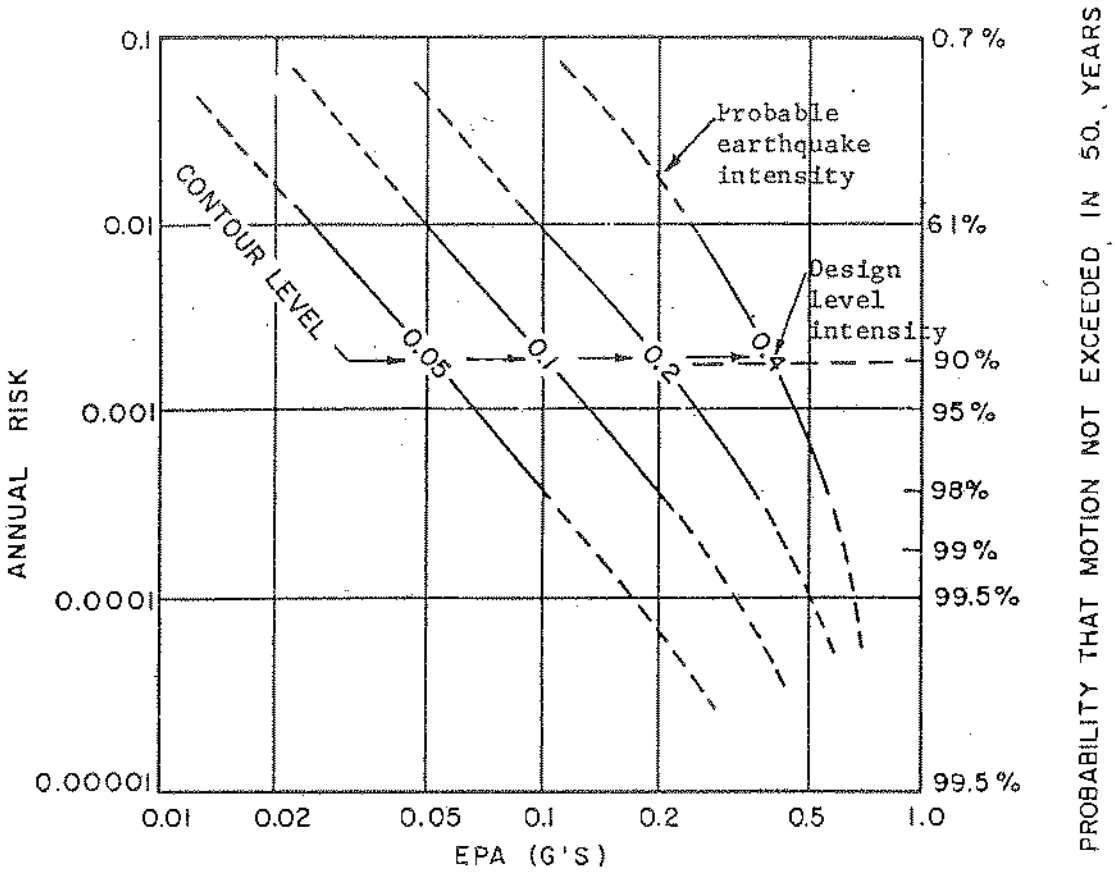
Reference, design documents (1982 UBC) for wind loadings specify a basic fastest mile wind speed of 70 mph for the Los Angeles basin. This would be measured at a height of 33 feet above ground in an area that is flat and generally open for one-half mile or more from the recording site. The reference states these wind speeds are associated with an annual probability of 2%. Horizontal loads computed by use of the specified height, exposure and gust factors, the pressure coefficient for the class of structure and the wind stagnation pressure vary from 9,600 lbs for the west tower, 8000 lbs for the center tower and 2,600 lbs for the east tower. These computed horizontal wind forces reasonably compare with previous computed design horizontal forces of slightly more than 7000 lbs for the west and center tower. The previous computations were made using somewhat different wind loading criteria.

Earthquake ground motions used for design in the Los Angeles basin assume the earthquake threat can be attributed to two separate events. The first is a great earthquake centered on the San Andreas fault system adjacent to the Los Angeles basin. The second event of concern is a large earthquake with an epicenter within the basin. This earthquake could originate on any fault system such as the Newport-Inglewood,

Raymond-Hollywood or Palos Verdes faults. In addition to the risk posed by these earthquakes, the Los Angeles basin could be shaken by earthquakes of lesser magnitudes on the described fault zones than that assumed for design level. Also, the basin could be shaken by large to moderate earthquakes on earthquakes centered on adjacent fault zones such as the San Jacinto Elsinore, Imperial Valley, Garlock - White Wolf or the San Fernando-Sierra Madre. Figure 2 (from ATC 3-06) indicates that the geographic areas within the 0.4 EPA design zone (the Los Angeles basin) have approximately a 2% annual probability of being shaken by a ground motion intensity of 20% of gravity. This level of ground shaking was selected as a probable earthquake for analysis of the towers.

To summarize, a design earthquake for the Los Angeles basin can be described as that range of ground shaking intensities that could be generated by a moderate to large earthquake on a near-site fault zone or a distant great earthquake. Design earthquakes are used for development of seismic design criteria for new buildings and earthquake hazard reduction studies. The design earthquake is not the largest possible or credible earthquake, rather it is generally described as that having a shaking intensity that has a 90% probability of not being exceeded in any 50-year span. If a structure is anticipated to have unlimited life, a 10% probability of higher intensity ground shaking than the design level exists. However, in the Los Angeles basin, the intensity of ground shaking that can be associated with the maximum or credible earthquake only exceeds design level by about 25%. The probable earthquake, as previously described, has an annual risk of about 10 times that risk associated with the design earthquake (figure 2). Use of probable earthquakes for analysis of structures is common practice to estimate earthquake damage. These analyses are coupled with studies of the performance of the structures for probable response to design or credible earthquake intensity levels. If the structure has a high probability of modification of elastic earthquake response due to increase in elastic period or adequate inelastic behavior, exceedance of earthquake design intensity only increases the excursions of the tower relative to the ground.

The weight of the west tower was calculated as about 37,500 lbs. From the 1959 lateral load tests, an elastic period of 0.6 sec was estimated. By use of elastic response spectra developed for the described probable earthquake (Figure 3), the magnitude of horizontal inertial forces can be estimated. This computation assumes the tower structure has the capacity to respond elastically to the design earthquake. Using the stated assumptions, the upper bound of probable elastic response is 0.4 times the tower weight or 15,000 lbs. force (see ⓐ, Fig. 3). Elastic modal analysis methods use response spectra techniques to determine deflected shapes of elastic oscillators. Elastic response theory is used to estimate deformation of elastic space frames or identical space frames that may have inelastic response (post-elastic displacements). These spectral response methods indicate the relative horizontal displacement of the center of the mass of the west tower and the base will be in the order of one and one-half inches if the elastic period of the structure is not modified by the dynamic elastic and inelastic response. If the period of the tower is lengthened by the dynamic excursions, the response



ANNUAL RISK OF EXCEEDING
VARIOUS EFFECTIVE PEAK ACCELERATIONS
FOR LOCATIONS ON THE INDICATED CONTOURS
OF EPA IN FIGURE CI-3

FIGURE 2

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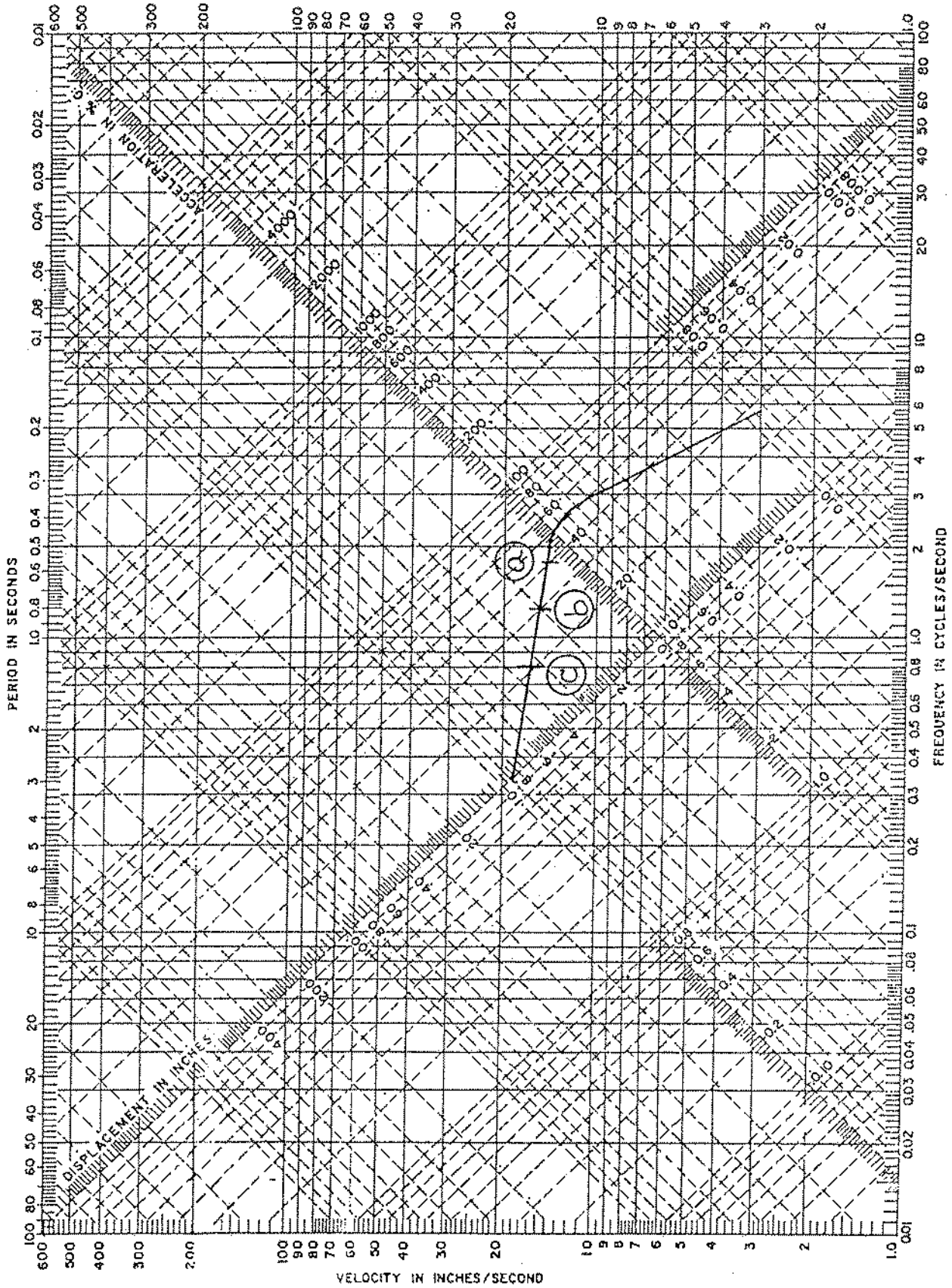

PERIOD IN SECONDS
FREQUENCY IN CYCLES/SECOND
VELOCITY IN INCHES/SECOND
ACCELERATION IN G'S
DISPLACEMENT IN INCHES
a
b
c

Figure 3

inertial forces are diminished to 11,000 lbs and the relative displacement will be increased (see (b) , Fig. 3).

Observed performance of composite concrete and steel structures indicates that this increase in elastic period is highly likely if the tower is shaken by probable earthquakes. If the elastic period of the tower is assumed to be increased by two, the inertial response forces are decreased to about 0.20 g and estimated relative displacement of the center of weight to the base is increased to about three and one-half inches (see (c) , Figure 3). Again the response inertial force assumes the tower has near-elastic structural performance.

A computed probable elastic response force for the center tower, using similar assumptions, is 8,000 lbs. base shear. This nearly matches the design wind base shear. For the west tower, the estimated earthquake base shear of 11,000 lbs. is considered to be equivalent to the computed wind base shear of 9,600 lbs. Estimates of the accuracy of computations indicates that the near-elastic displacements of the towers will be similar for wind or probable earthquake effects. When probable dynamic time-histories of wind loadings and earthquake motions are considered, relative displacements of the towers relative to the ground may be largest for wind effects.

7. PROBABLE PERFORMANCE OF THE TOWERS WHEN SUBJECTED TO HORIZONTAL LOADINGS

As stated previously, the structural load test made in 1959 did not define the upper bound of elastic performance of the west tower. Our computations made to estimate element stresses and deflections indicate that the elements of the spaceframework resisting horizontal displacement between bands were functioning as centrally reinforced concrete elements. Micro-cracking in the mortar covering had reduced the composite elements' stiffness in zones of high moment. Further computations indicate that member strength reductions are not caused by this micro-cracking. Such behavior is common to concrete-steel composite structures and indicates desirable performance for concrete-steel composite structures constructed in seismic hazard zones.

Our estimates of the elastic capacity of the load-tested west tower are comparable to its probable elastic response to probable earthquake ground motions. This indicates that inelastic behavior of its space frame is a small to moderate probability, if the site is shaken by the described probable earthquake. A similar comparison of the load-test determined elastic capacity of the west tower and the design wind load indicates a probable elastic response to wind effects, if the tower structural framework had no corrosion deterioration. Estimates of current elastic capacity indicate a small probability of inelastic behavior under design wind effects.

Inelastic behavior of the space frames of Simon Rodia's towers can be described as cracking of the mortar covering of the steel cores adjacent to the bands, relative longitudinal movement of the steel cores of the vertical legs at the original splices and at the repaired zones,

and cracking between the junctures of the columns and the bands, spokes and braces. This inelastic behavior of the space frame will be concentrated in members described in Table 2 as "high stress."

TABLE 2

CATEGORIZATION OF MEMBERS FOR LATERAL LOADS

Columns:	Part of lateral load support system--high stress
Center Core:	Part of lateral load support system--high stress
Bands on columns:	Part of lateral load support system--high stress
Bands on loops:	Not part of lateral load support system except for self-support
Loops:	As above
Spokes:	Part of lateral load support system--high stress near base, moderate to low stress elsewhere
Braces:	Part of lateral load support system--low stress

Inelastic behavior of this brittle system (mortar covering over steel core) during an earthquake or wind storm is not desirable, but is a small to moderate probability. Corrosion causing diminishment of the area of the steel core and bursting of the mortar surrounding the metal core can cause a serious reduction of the original resistance capacity of the space framework. Repair of corrosion damage and reduction of the rate of continuing corrosion is most important in the members noted in Table 2 as high stress and further defined as critical members.

A critical member in the space framework is a member that has a probability of compression buckling and thus a complete loss of gravity load capacity. Secondary members increase the stability of the critical members. Loss of a secondary member may not precipitate buckling of a critical member if the critical compressive capacity of the then-unbraced member is not exceeded.

Loss of tensile capacity of a column is not critical if the member can retain a compression load capacity on subsequent loading. Dynamic loads due to wind storm or earthquakes are time-dependent and the displacements upon tensile separation are limited by the probable time-history parameters inherent in any dynamic loading.

The described inelastic behavior will also cause a reduction of the elastic stiffness of the towers. Corrosion and resulting deterioration will also cause a reduction in the elastic stiffness of the towers. However, diminishment of stiffness of the existing structure during earthquake ground shaking is not in itself hazardous. Diminished stiffness decreases inertial response forces.

The space framework near the base of the towers is the critical zone for prediction of the probability of major damage to the vertical load-carrying system and/or a partial collapse. The width of the base, the redundancy of the vertical load-carrying system, and the low to moderate vertical load stresses, indicate probability of total collapse of any tower is nil to very small.

In our opinion, response to earthquake motions and wind loads will be near identical for all parts and elements of the walls and minor structures connected to the towers. The probability of inelastic behavior in the braces of the towers on the "ship," the braces interconnecting the towers and the perimeter walls and the pergola members adjacent to the central spire is small to moderate when displaced by probable horizontal loads. The probability of collapse or a complete loss of vertical load-carrying capacity of the vertical support elements is small.

8. PROBABLE LIFE-SAFETY HAZARDS CAUSED BY HORIZONTAL LOADINGS

In general, probable life-safety hazards will be caused by separation of parts of the mortar covering of the steel core. Moderate or major damage to the space framework, as described in the probable performance section, will be characterized by separation of substantial quantities of the mortar covering. Because threats to life and limb must be given a higher rating as the falling height of an object above a person increases, damage to the towers in the upper part and in braces overhead of viewers must be given a more critical rating than damage near the base of the towers.

Deflection of the tower structure relative to its base caused by horizontal loads may cause cracking of the mortar covering and subsequent localized loss of the covering. Corrosion of the steel core may also initiate separation of the mortar covering for wind storms or minor earthquakes. Therefore, when the annual risk of separation of a substantial piece of the covering of the framework at a significant height above a viewer is considered, the risk posed by uncorrected corrosion of the metal core may exceed the annual risk posed by a probable earthquake or design windstorm.

In any event, procedures such as access control, protective screens or headgear can reduce the life-safety threat to a level acceptable to a viewer and the operating agency. Since possible injury to a person must include the coincidence of a person and a falling piece of mortar of substantial size, the probability of threatening the life and limb of a significant number of persons is very small. When the life-safety threat of Simon Rodia's towers is measured against the total number of existing structures in the Los Angeles basin that may constitute a life-safety threat in the event of a probable earthquake, that portion of the risk posed by the towers is very small or nearly insignificant.

9. PROBABLE DAMAGE TO THE HISTORIC FABRIC BY HORIZONTAL LOADINGS

Damage to the historic fabric is now occurring due to corrosion of the metal core. This deterioration increases the potential of substantial

damage from wind or earthquake and poses a small potential of severe damage.

Probability of damage to the historic fabric due to extreme winds is very small due to the small probability of design wind storms in the Los Angeles basin and the magnitude of horizontal loading caused by a design wind. However, continuing corrosion diminishes the original continuity of the framework and increases the probability of significant damage to the towers by wind loading.

Damage to the historic fabric due to earthquakes of design level intensity becomes moderately probable if the life of the towers is extended by 50 to 80 years. Damage to the historic fabric by a probable earthquake is a small probability. This is due to the small annual probability and the magnitude of estimated earthquake response forces. Again, continuing corrosion diminishes the continuity of the framework and increases the probability of significant damage to the towers by a probable earthquake.

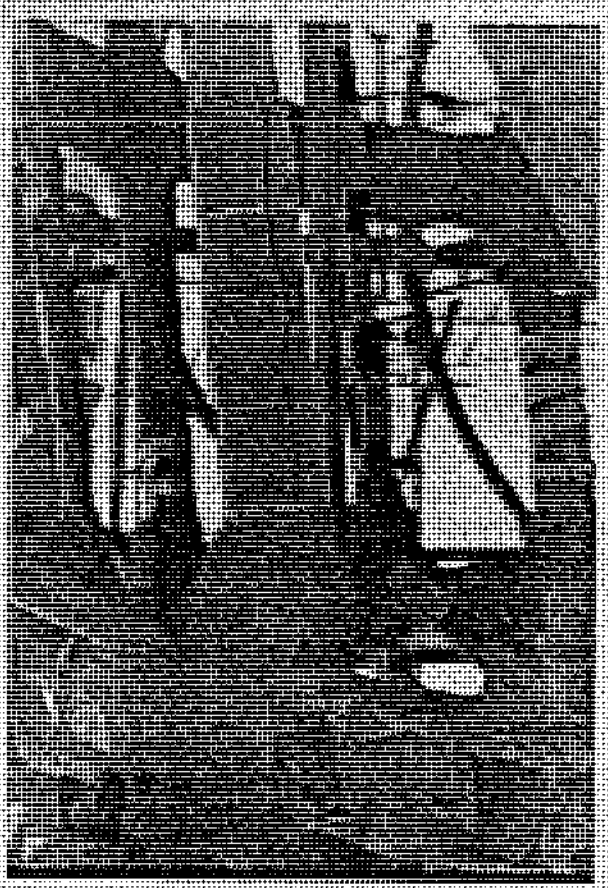
10. COMPATABILITY OF RECOMMENDED REPAIR TECHNIQUES WITH STRUCTURAL INTEGRITY

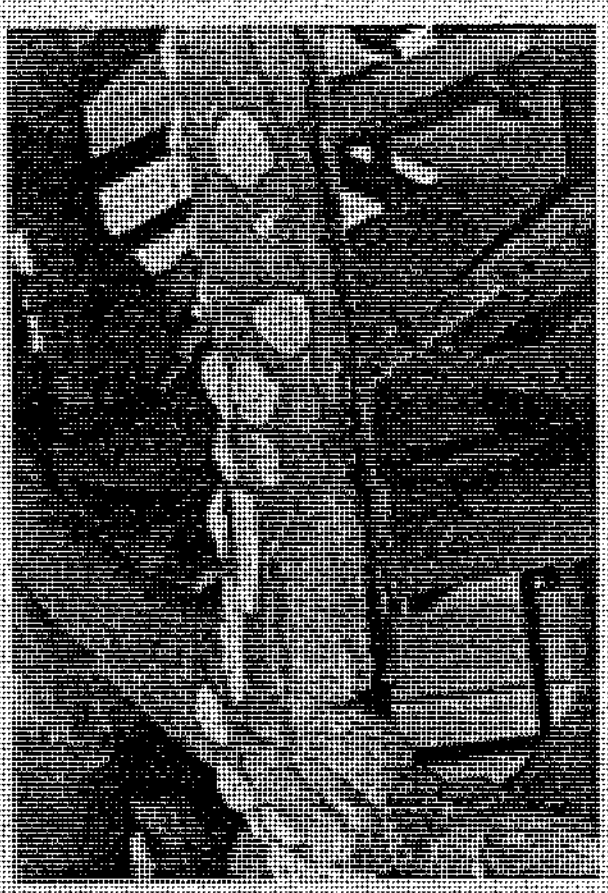
Recommended repair techniques can be generally described as placing a high priority on salvaging and replacing the historic texture and decoration. Replication of the historic textures and decoration is recommended only for repair of members defined as high stress (Tables 1 and 2) in critical zones. Replacement of now completed repairs is not recommended unless continuing corrosion is discovered in these repaired zones.

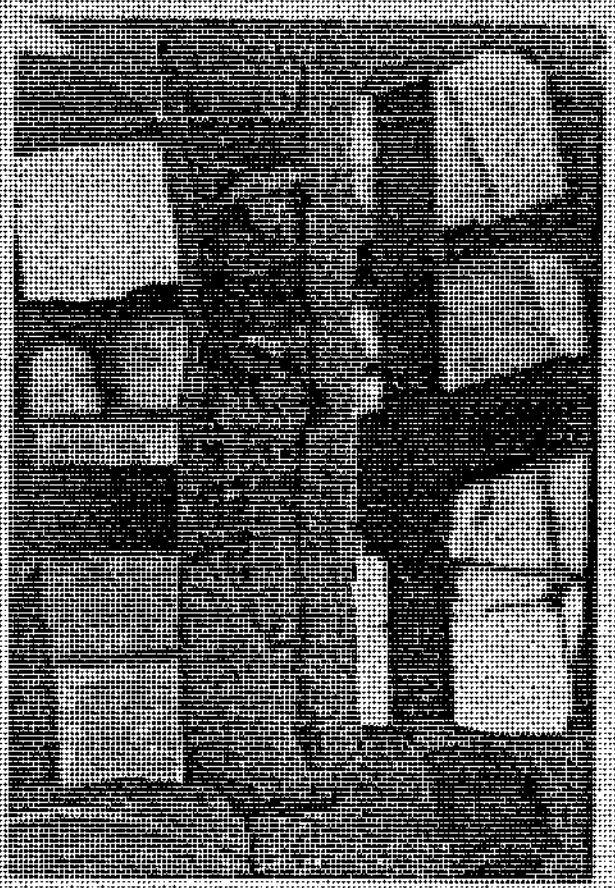
These repair procedures are intended to replace the corroded structural section with a substitute member. In the first case, where salvage and replacement of historic fabric is recommended, the reinstallation of the fabric must be effectively bonded with the protective mortar and lathing placed around the existing or replaced metallic core. Tensile, compressive and bending moment capacity must be retained, as near original capacity as possible. The repaired zone will not be equal to the original structure for tolerance to deformations in the inelastic range. In the second case of recommended repair, the priority is to duplicate the original strength of the repaired member and further, retain the original capacity of that part of the structural framework to tolerate displacements in the inelastic range.

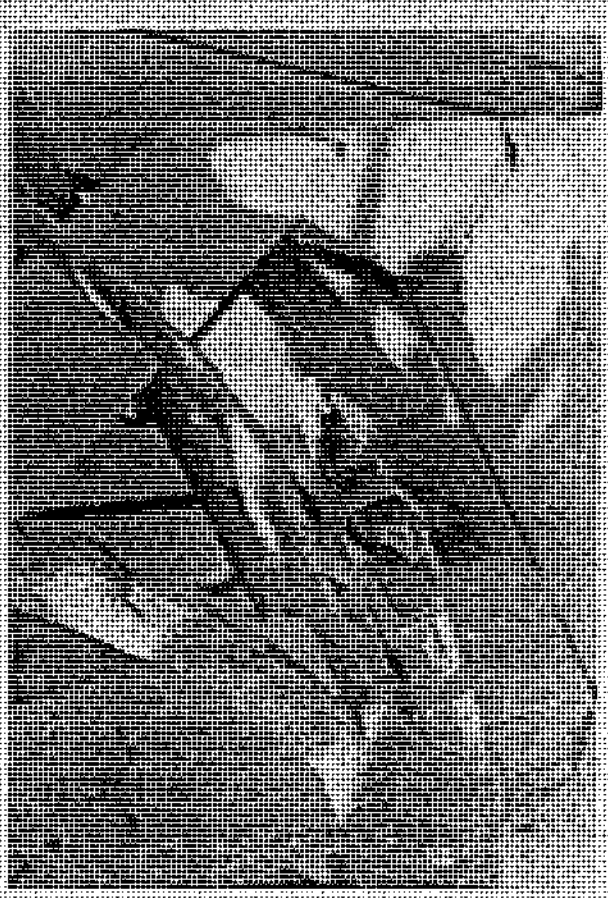
The recommended structural repair techniques were developed to match the need for inelastic behavior in parts of the tower that provide gravity support of the tower and that may have inelastic elongations under horizontal loadings. Secondary members are repaired with recognition that the original structural capacity of the towers is not duplicated. This procedure is in accordance with the structural analysis criteria previously described.

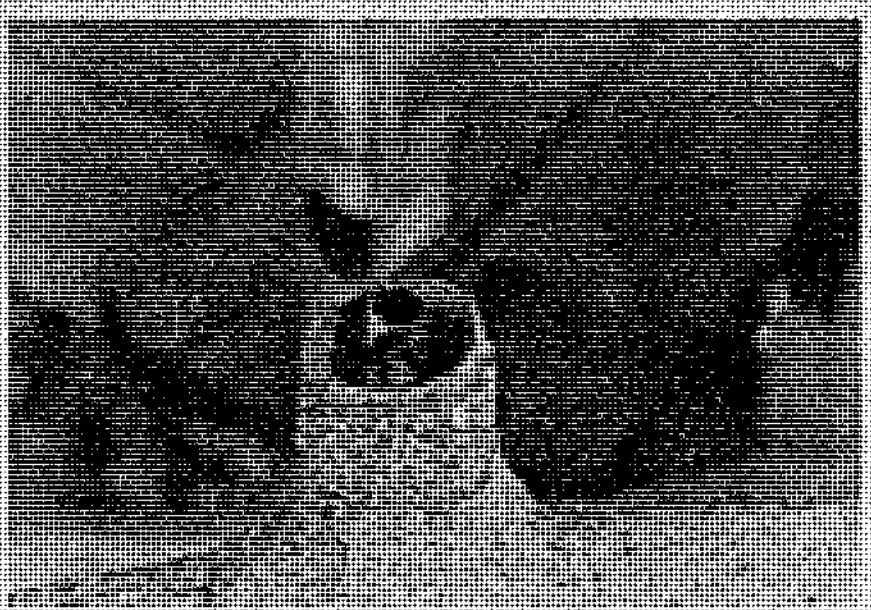
11. RECOMMENDED STRUCTURAL REPAIR TECHNIQUES are specified in Part 2, Section IV D.

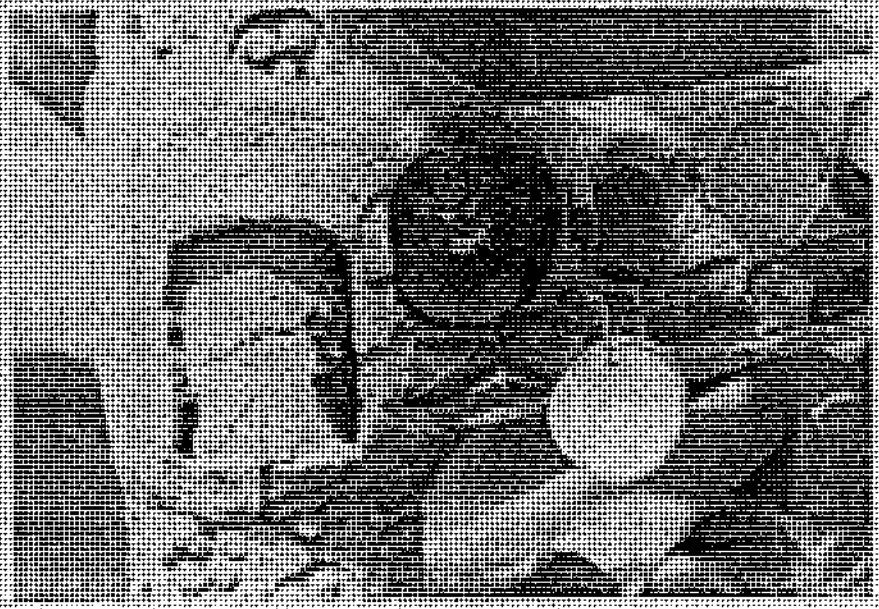


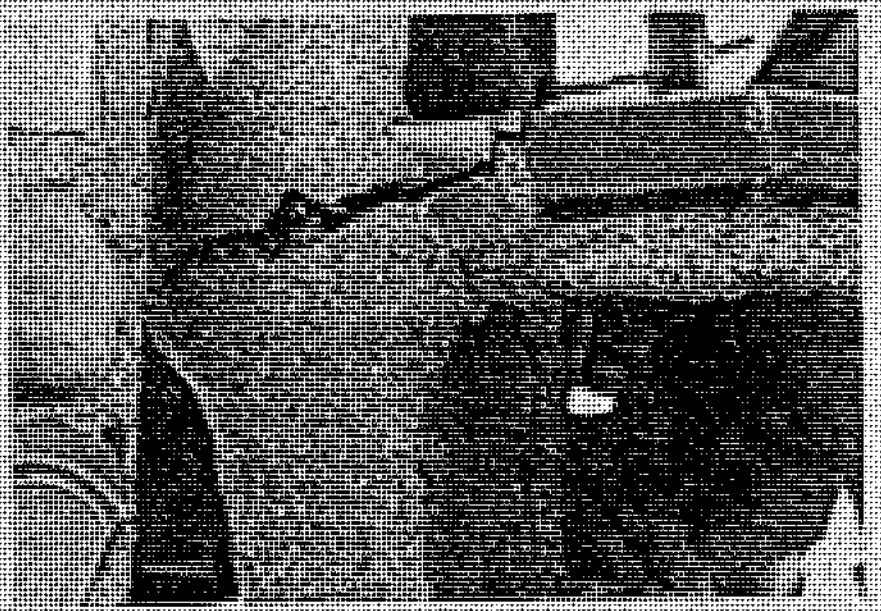


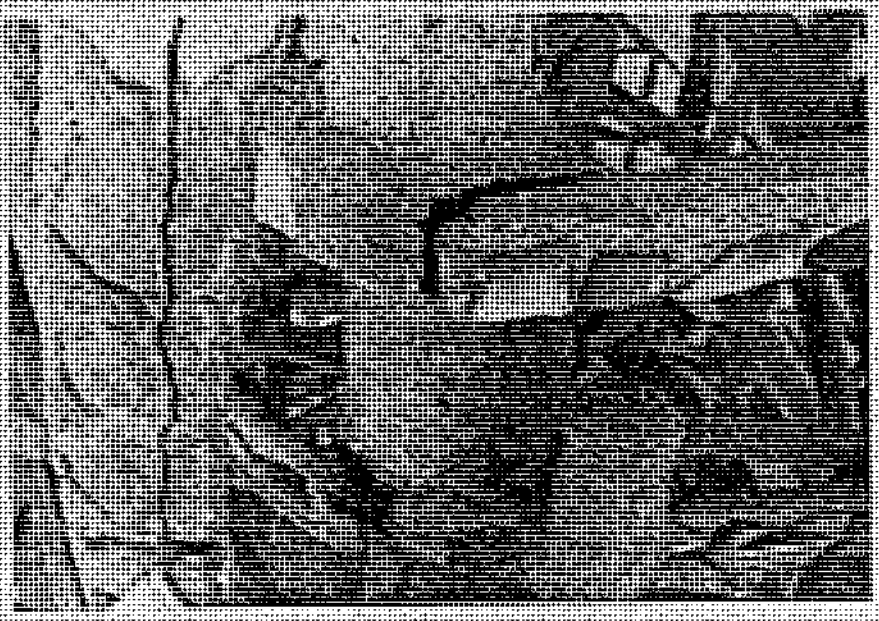


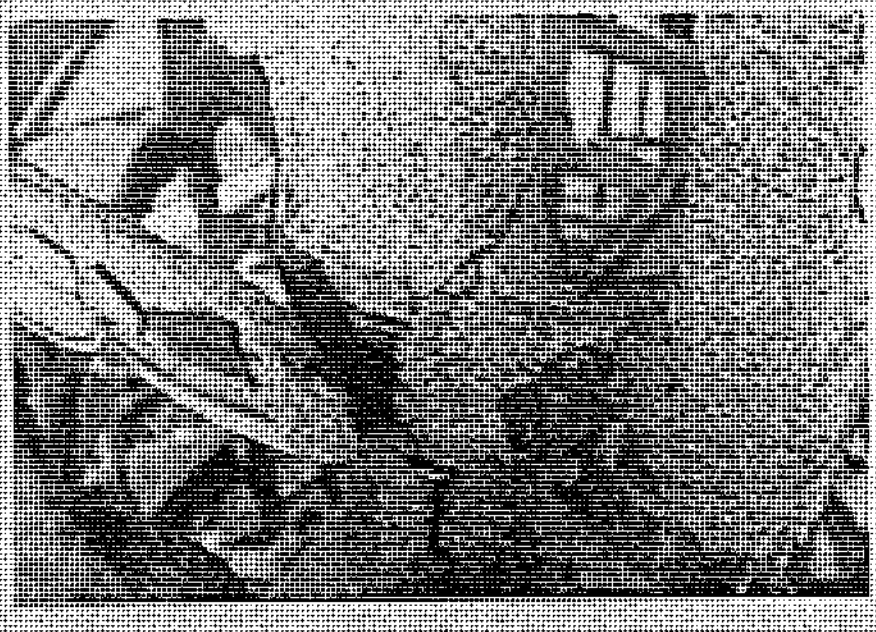


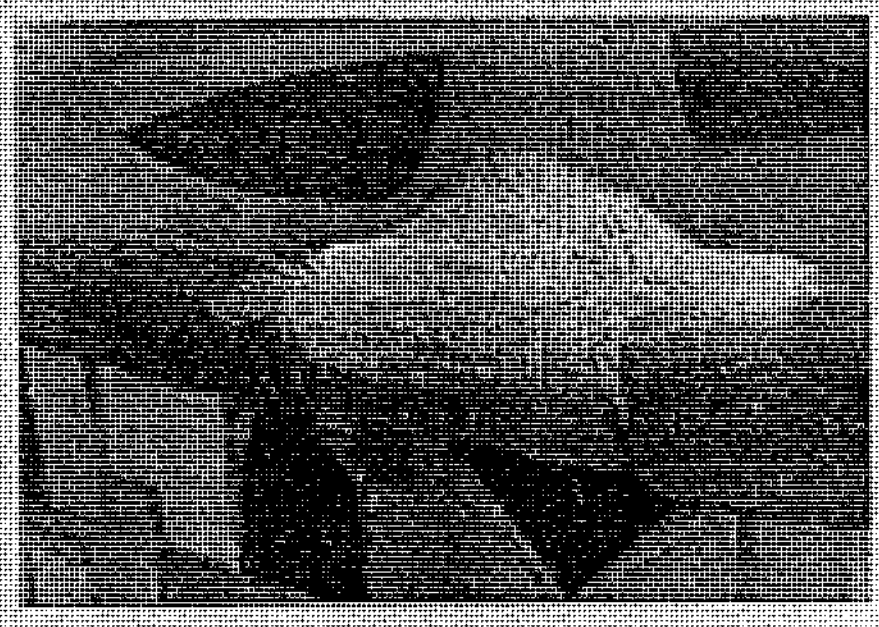


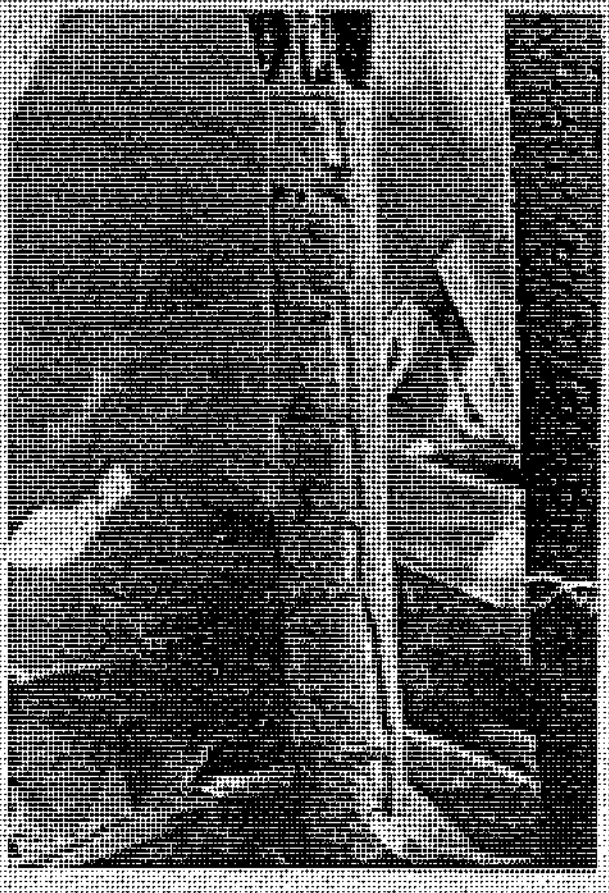


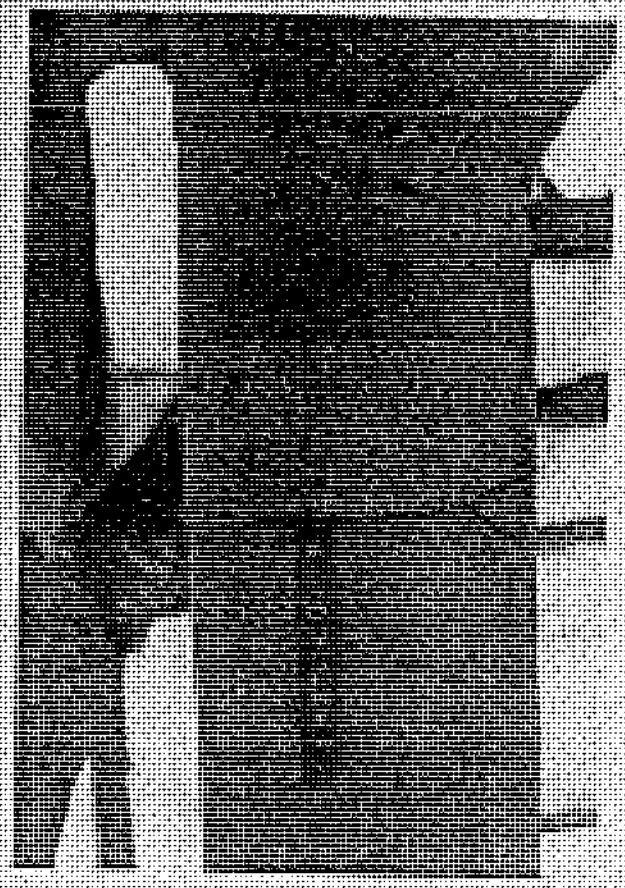


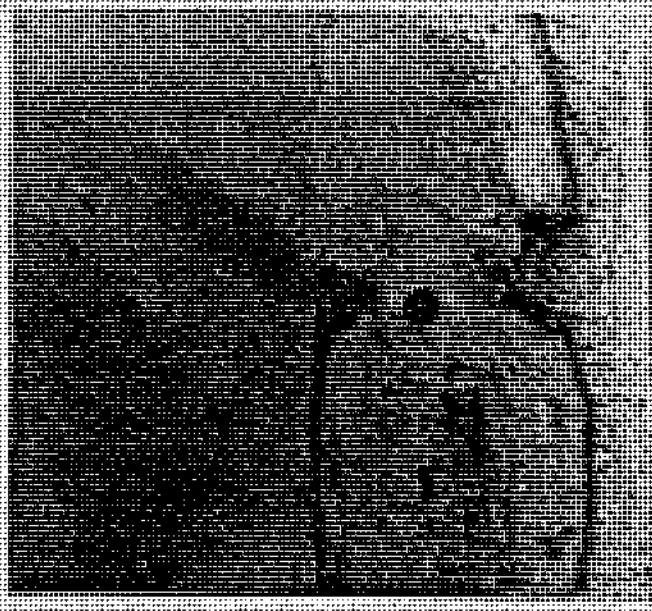


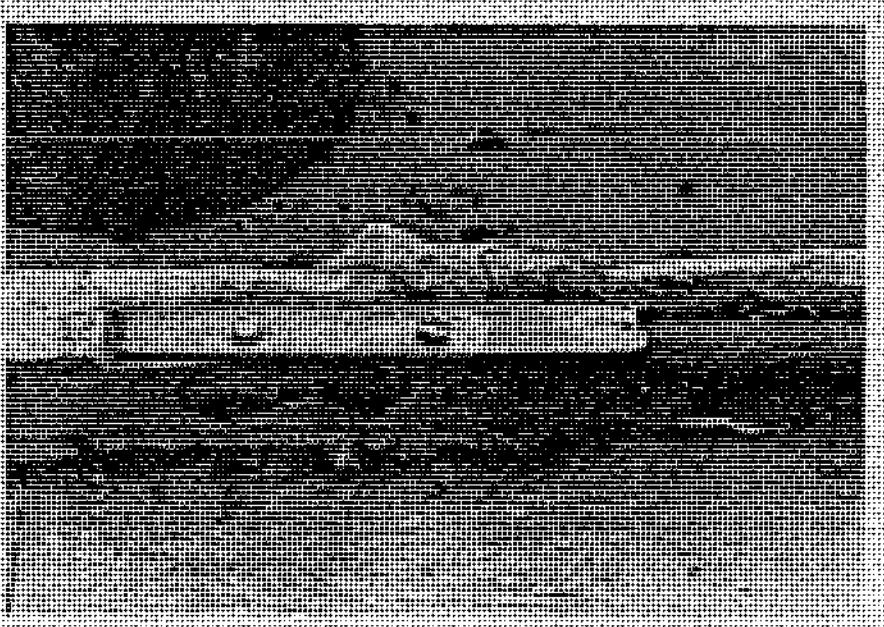


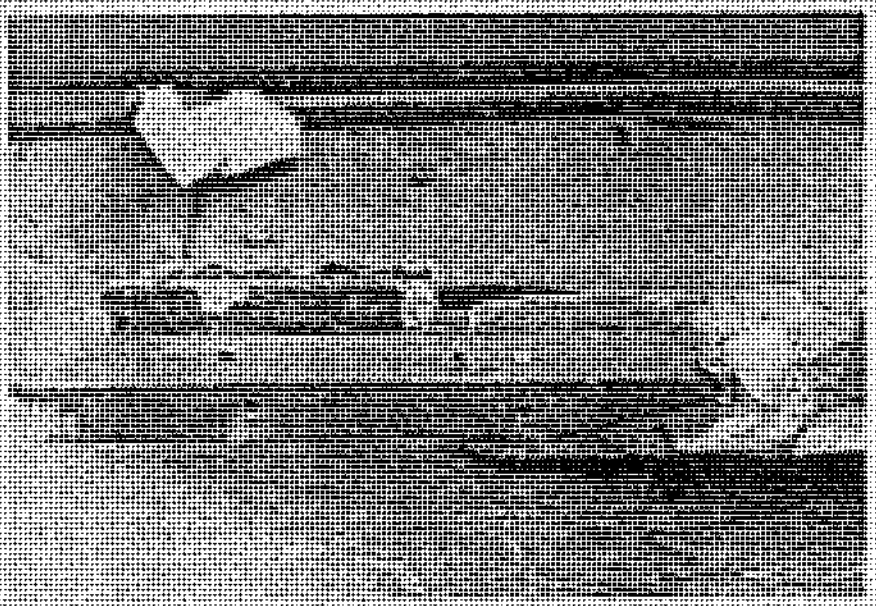


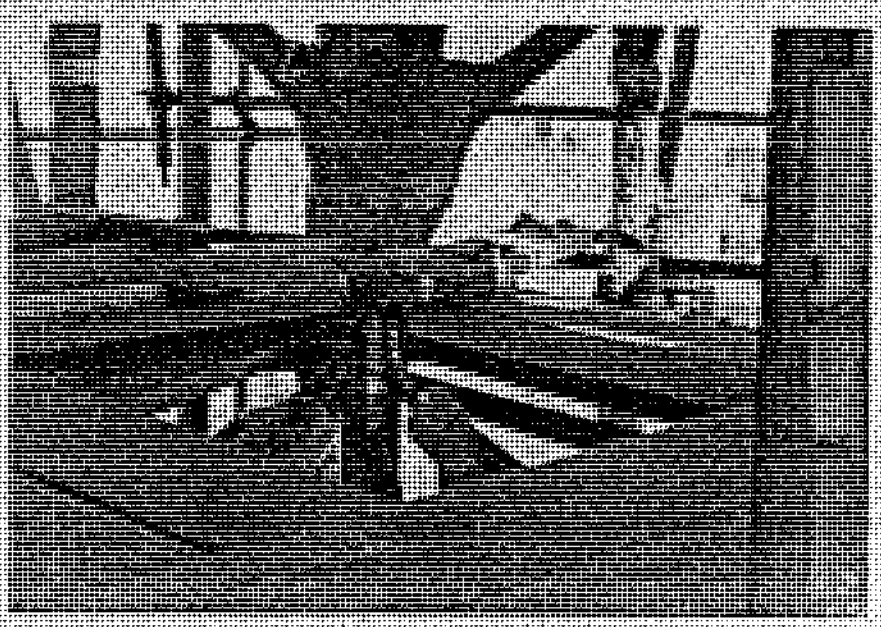


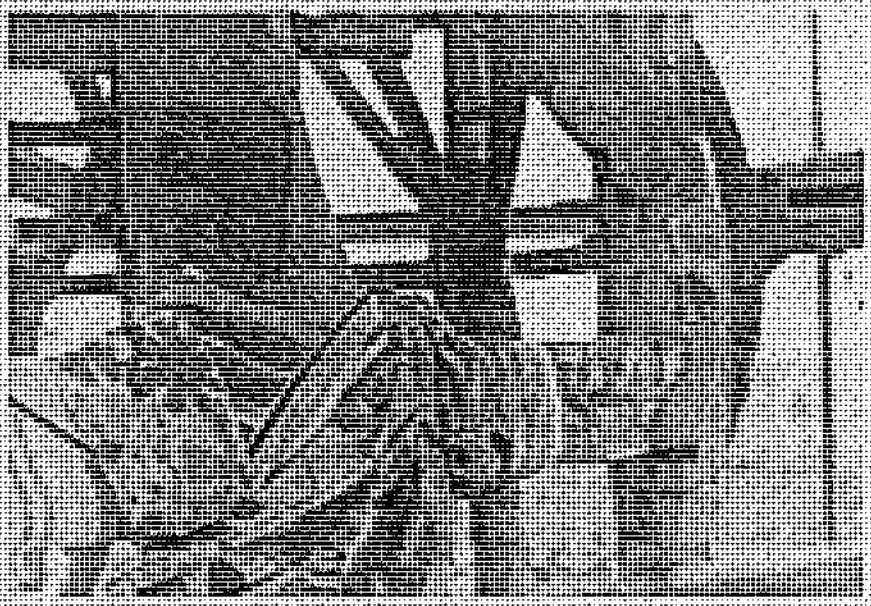


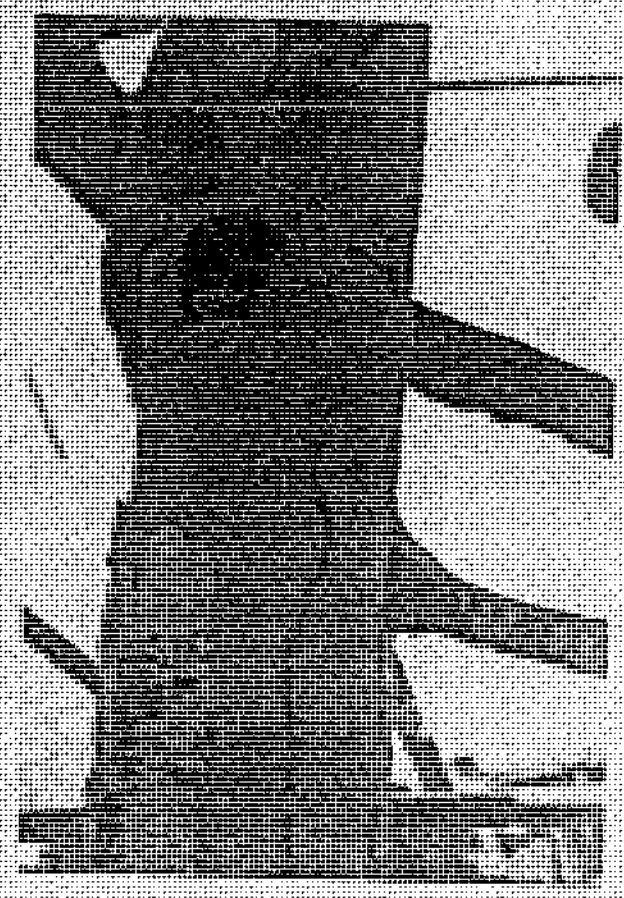


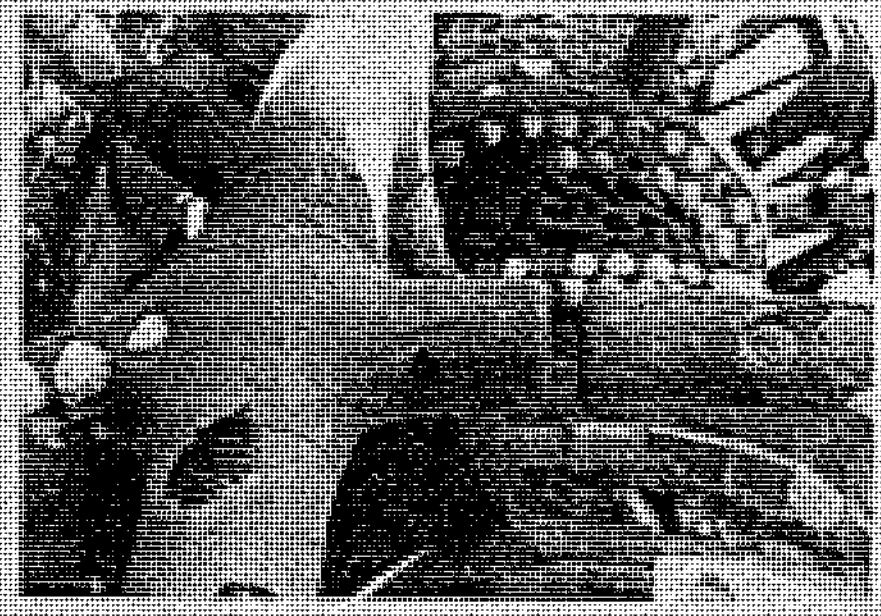


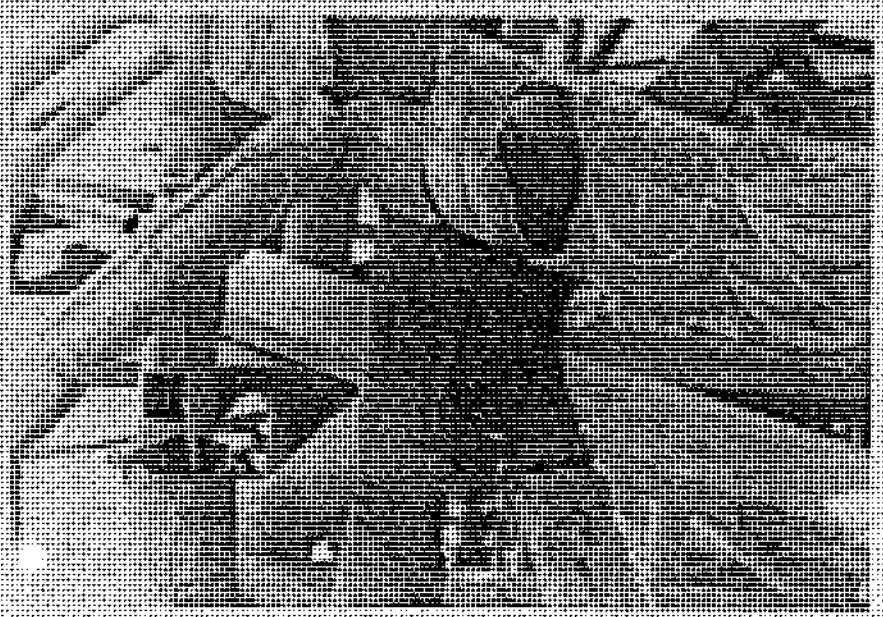


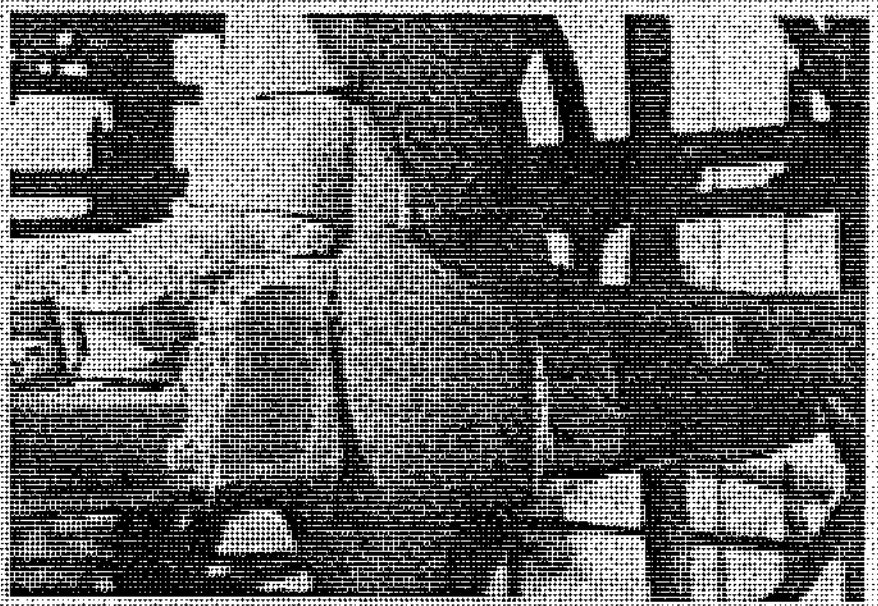


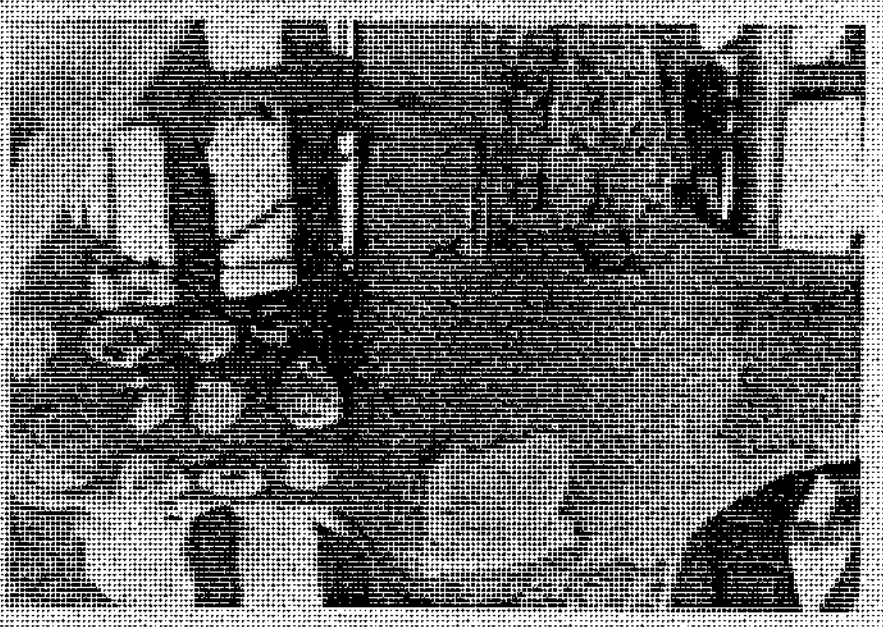












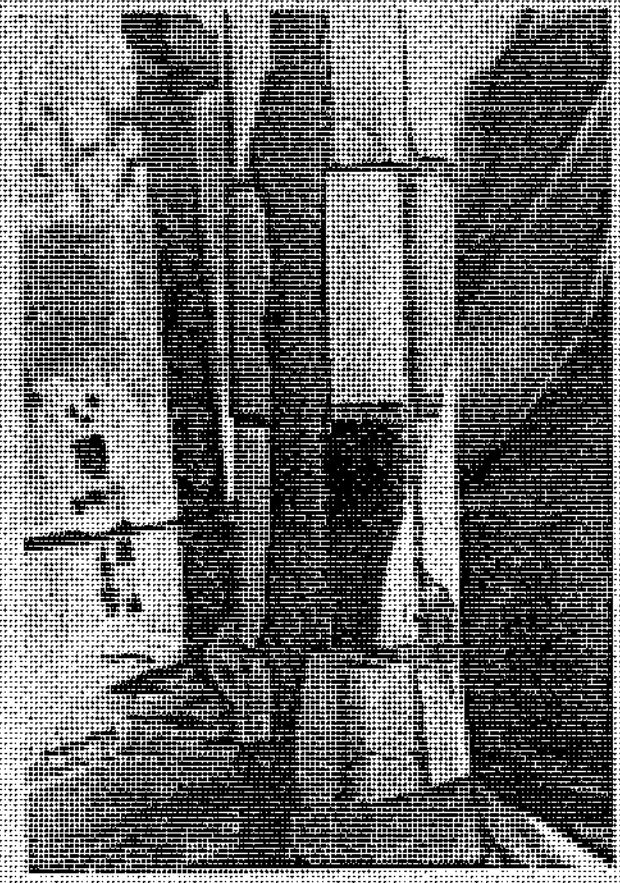


Figure 18. Cracks in repaired area. Column at base of east towers.

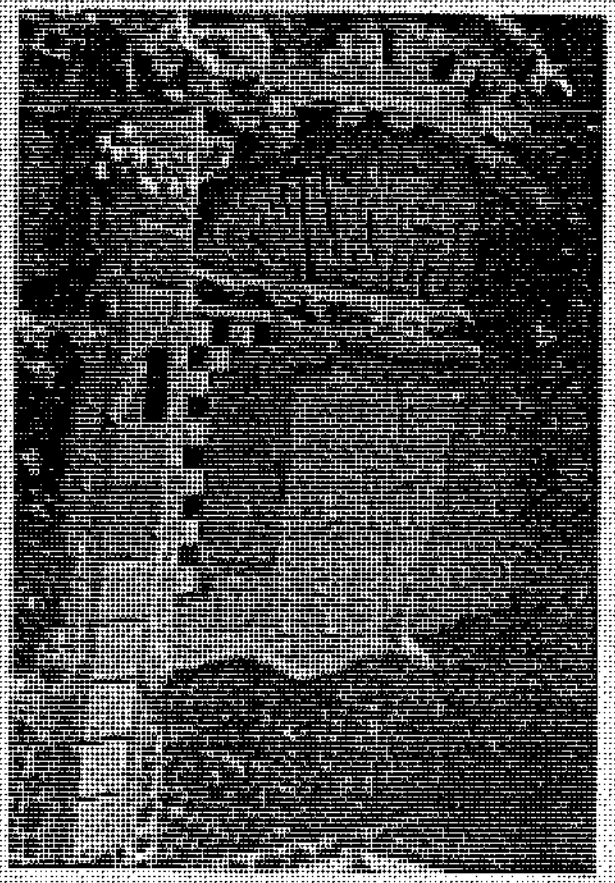


Figure 19. Typical panel on outer side of south wall. Embedments include glazed architectural tile, rocks, shells and glazed pottery.

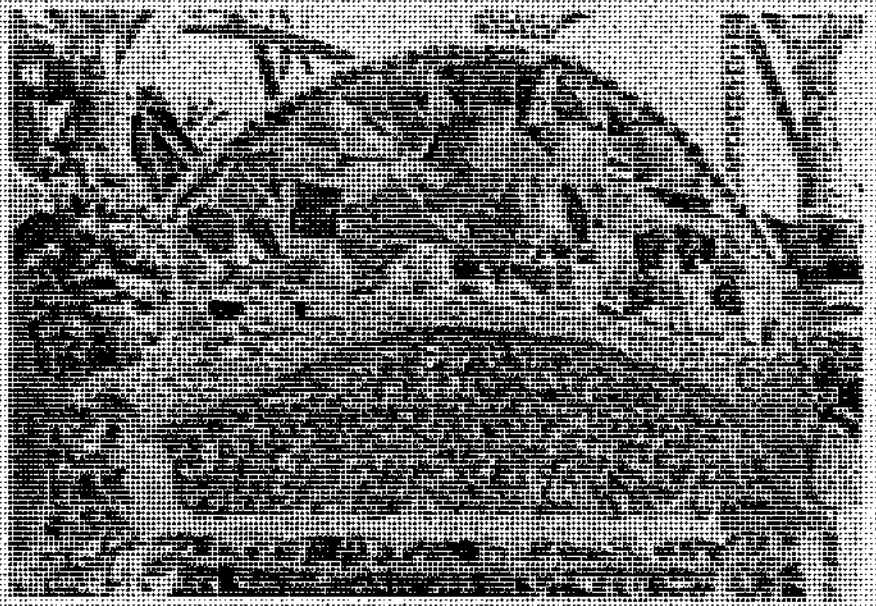
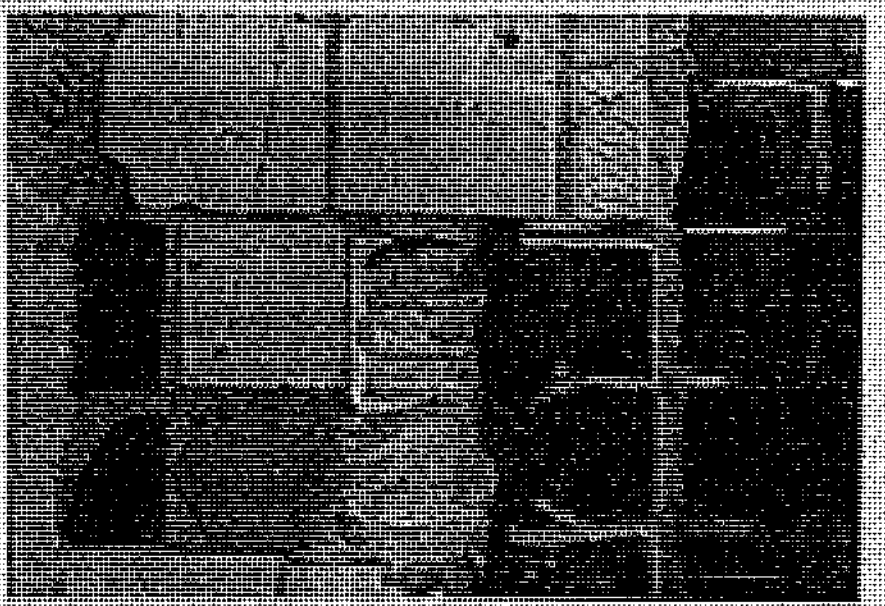


Figure 20.

Detail of top of panel on outer side of south wall.



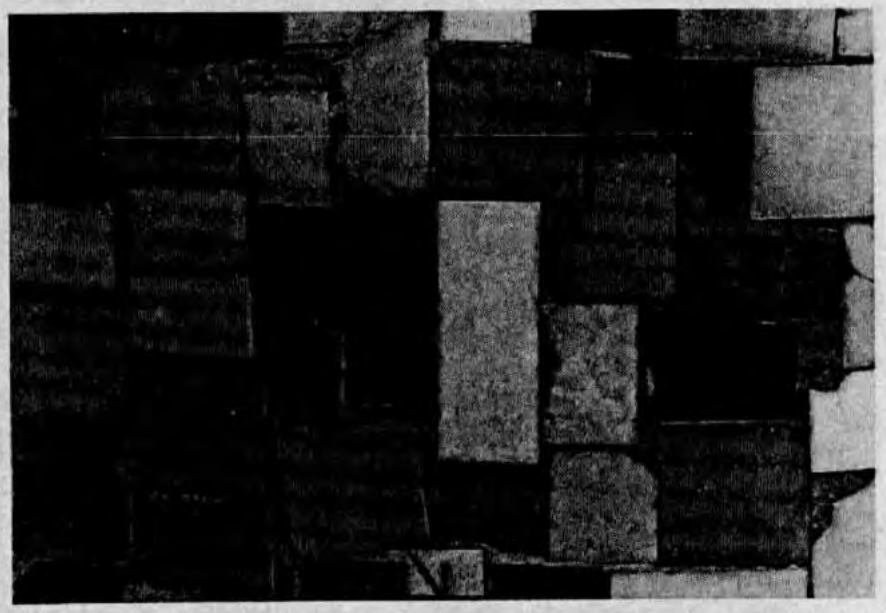


Figure 44

Detail of randomly-applied glazed tile on south wall. Irregular joints between tiles are generally not filled with mortar.

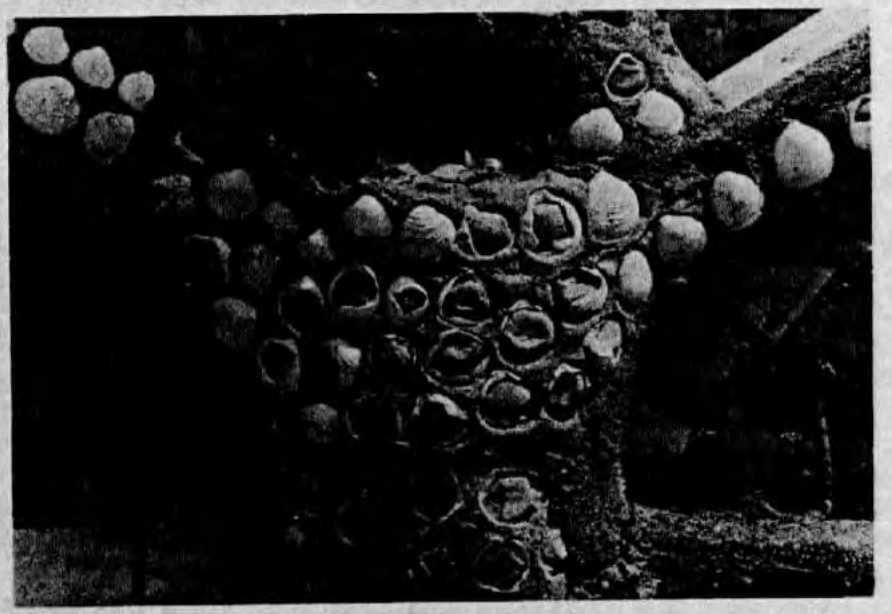


Figure 45

Pilaster between panels on south wall, showing typical condition of shell embediments. Note also cracks between different mortars.

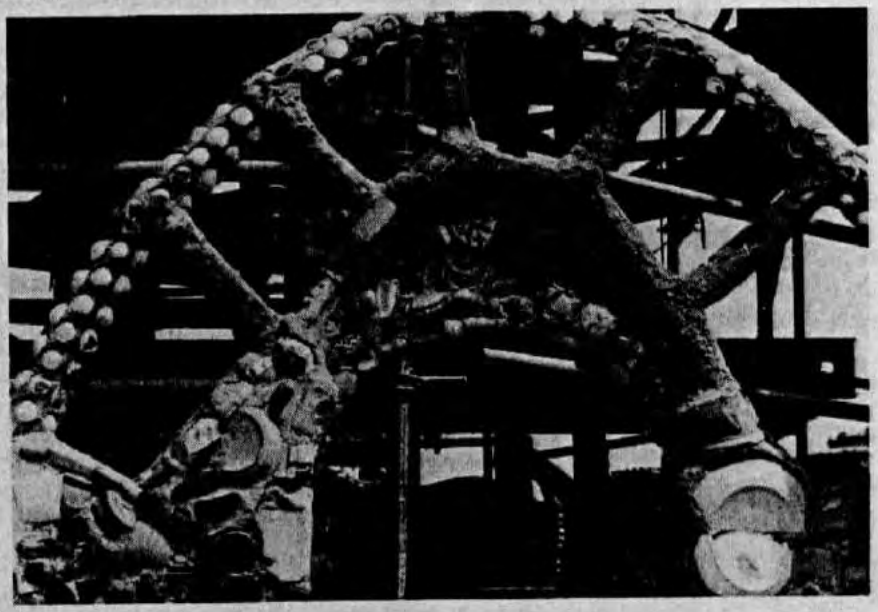


Figure 46

East gate on south wall. Note cracks and spalling on left side.

Figure 47 Cracked concrete and corroded iron on back (north) side of east gate.

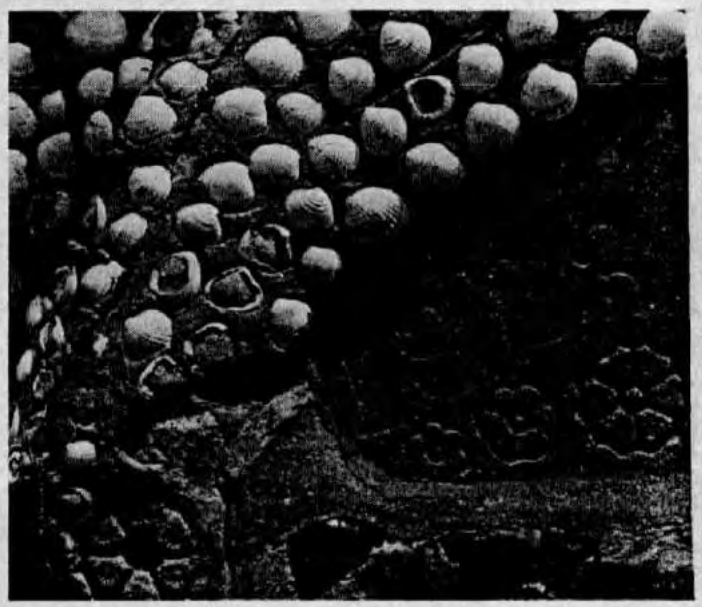


Figure 49 Top corner of panel on south wall showing cracking between various mortar types. Crack above "1923" runs through material.

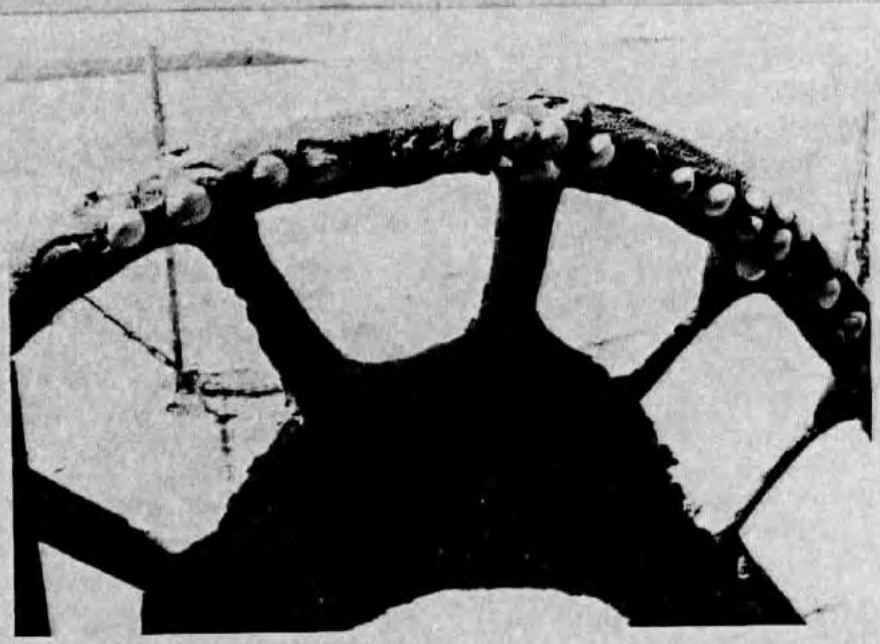


Figure 48 Inner side of arch arch over east gate. South wall showing corroded framing.

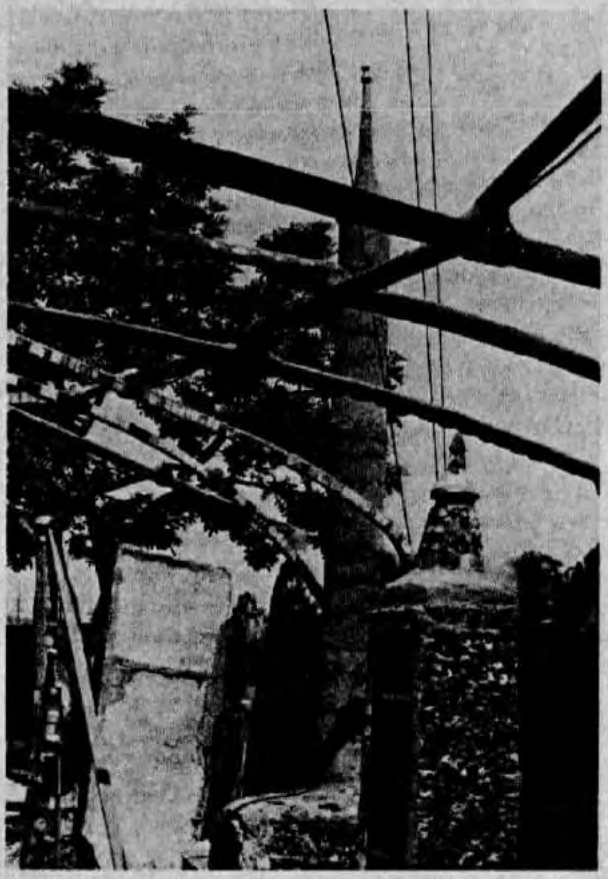


Figure 50 Gate, barbeque, benches, north wall.

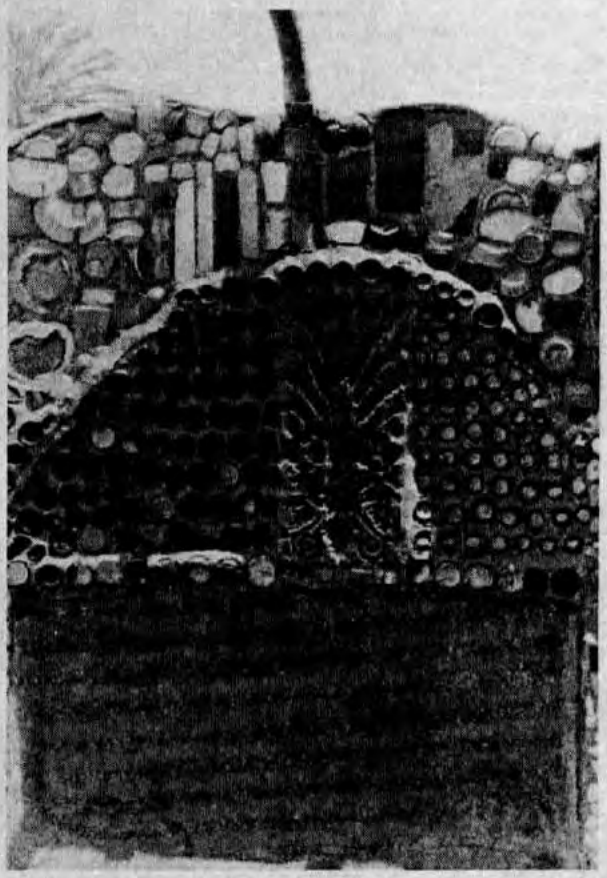


Figure 51 Typical panel, inner side of north wall.

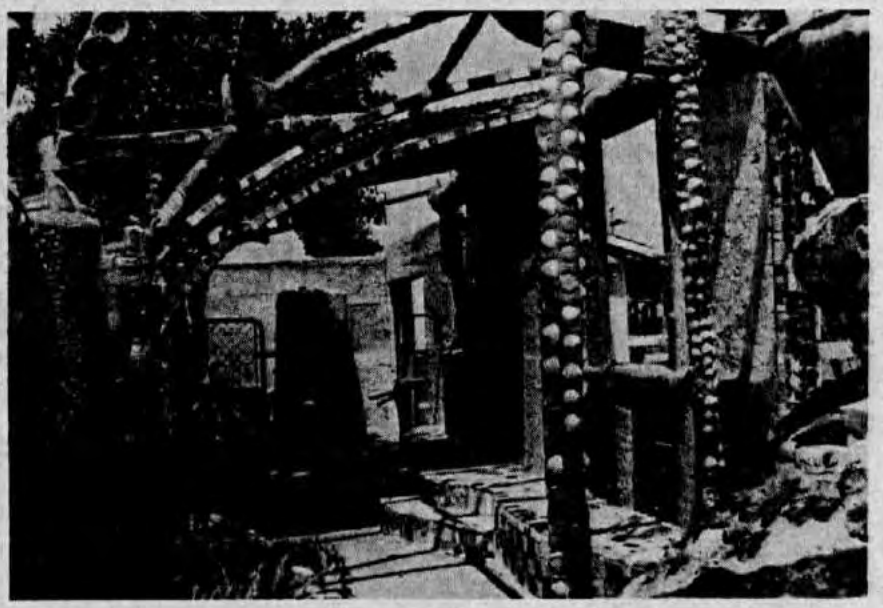


Figure 52 Entrance to Rodia's house.

Figure 53 Crack between beach and south wall of house.

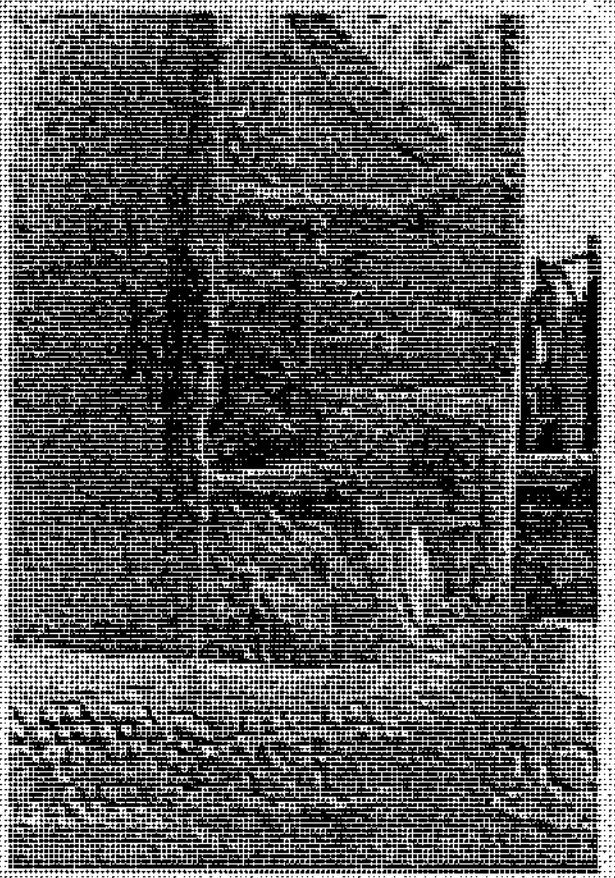


Figure 54 Detail showing cracked mirror embedments adjacent to door to Rodia's house.

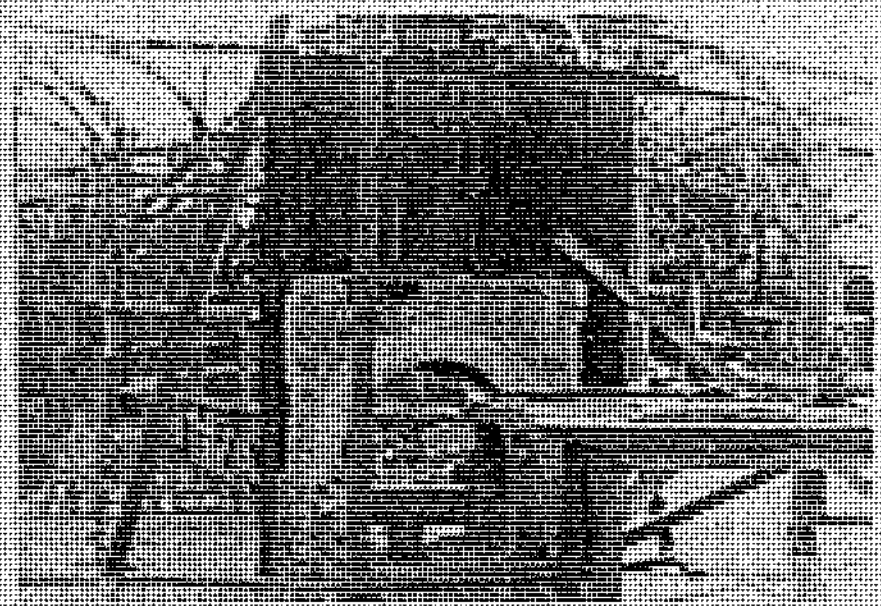


Figure 55 Fireplace in Rodia's house.

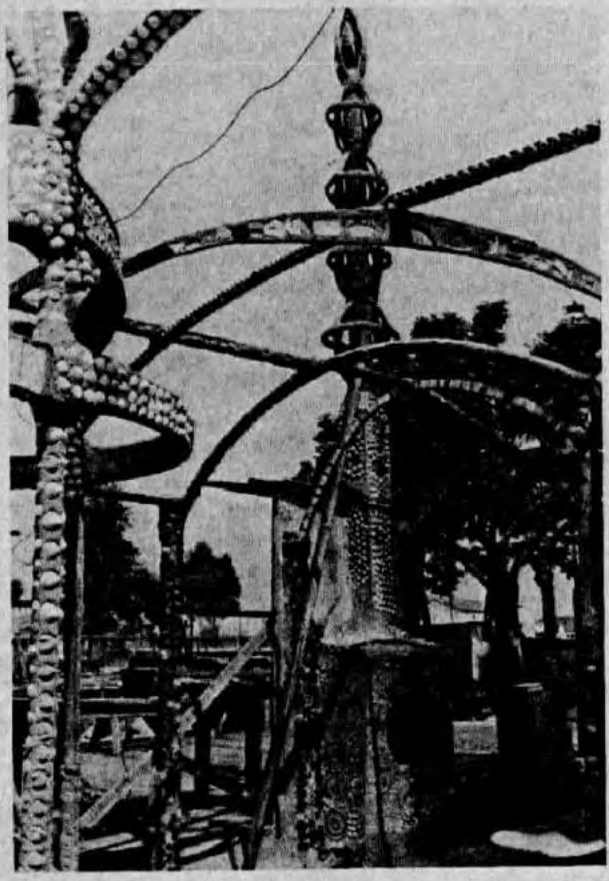


Figure 56 Exterior chimney wall.

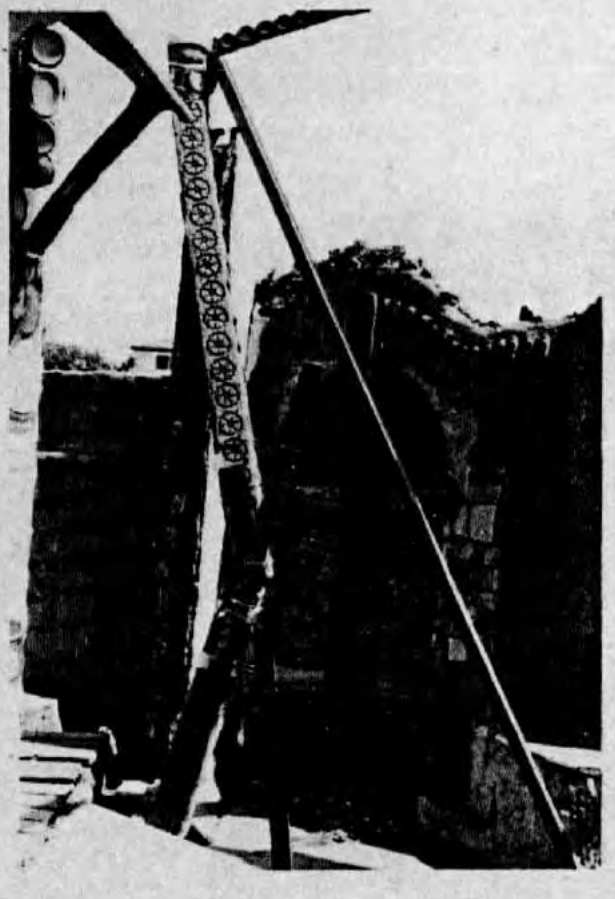


Figure 57 Broken pilaster in northeast corner of House. Note also original gate and cracking in east side of doorway on north wall.

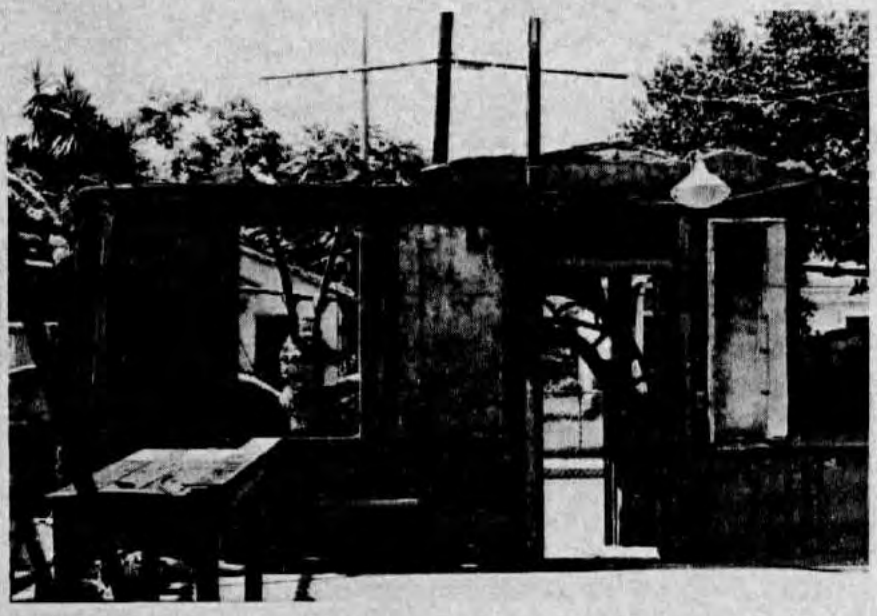
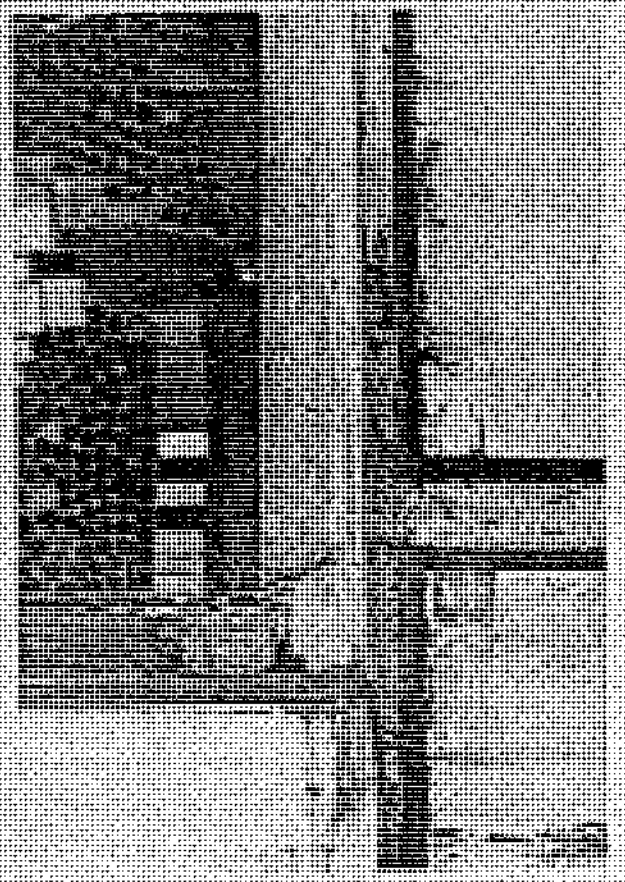
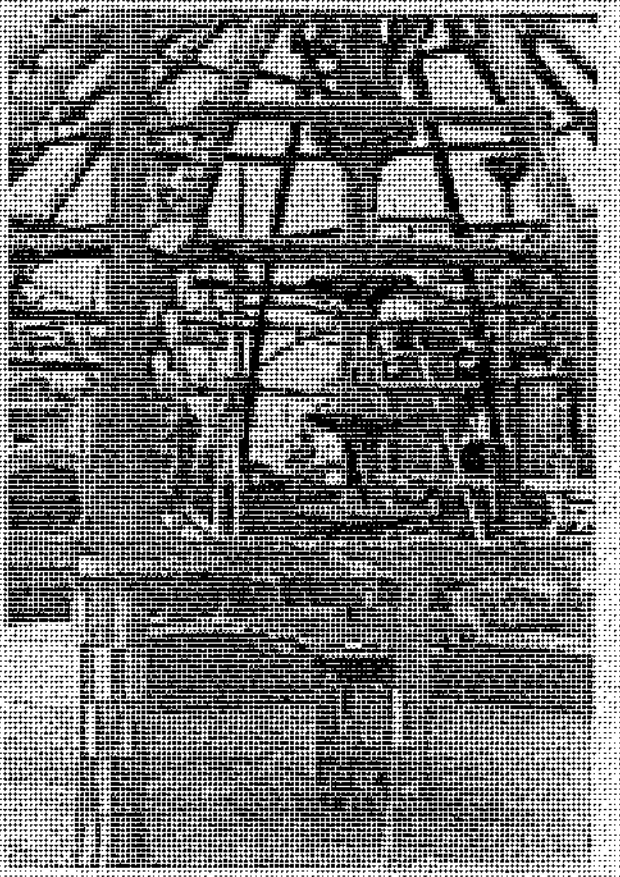
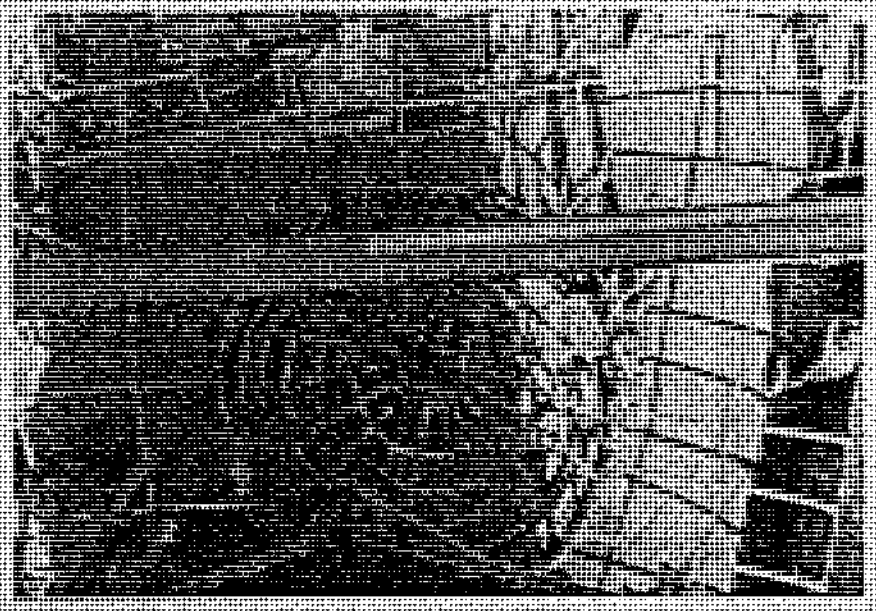
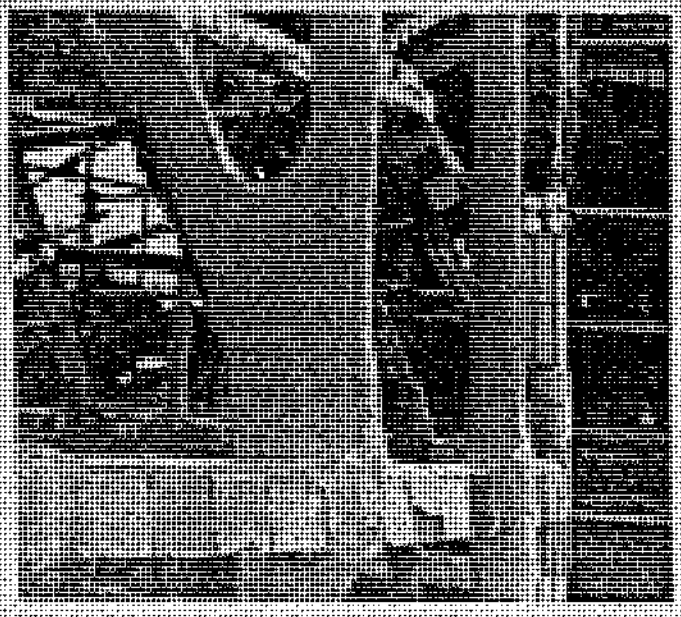


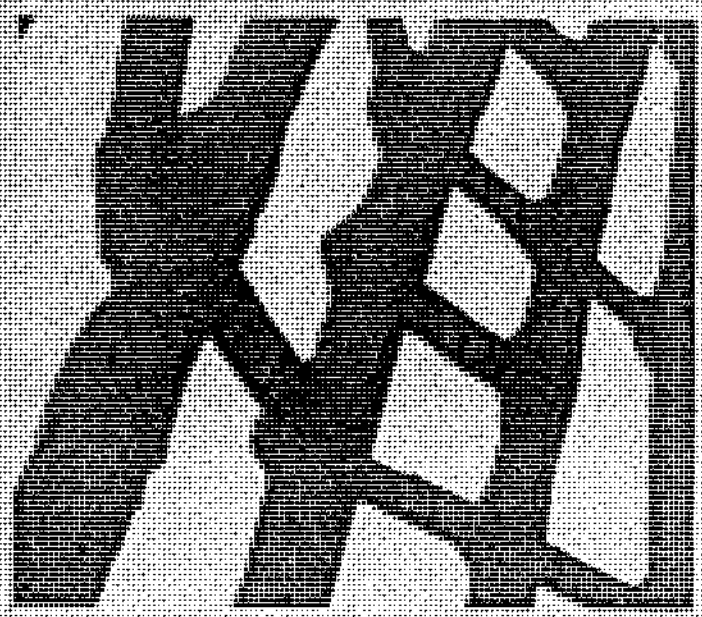
Figure 58 Inner side of south wall of Rodia's House.

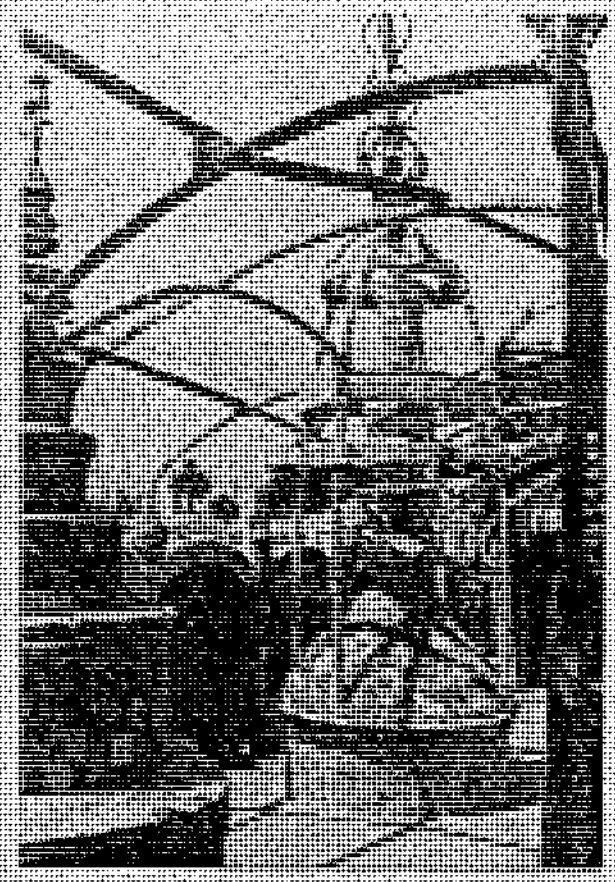


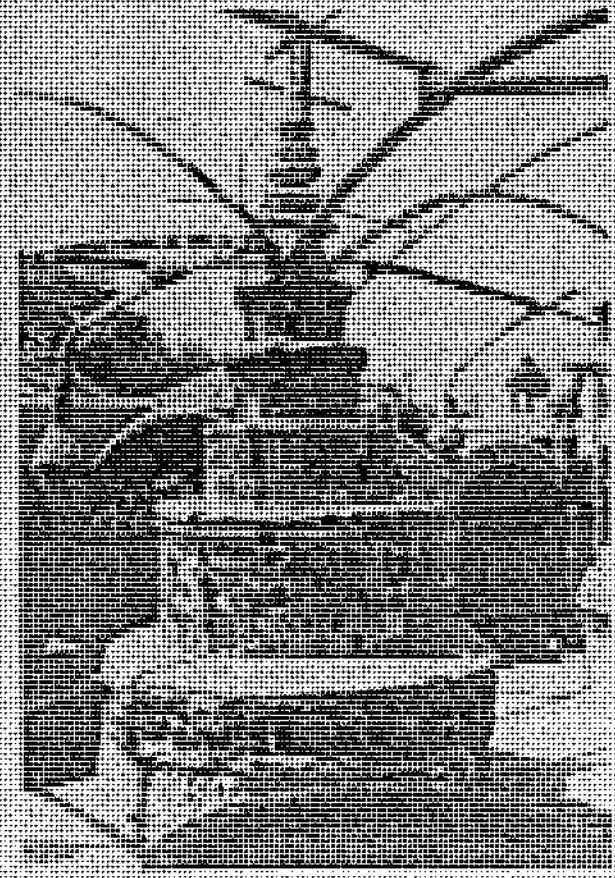


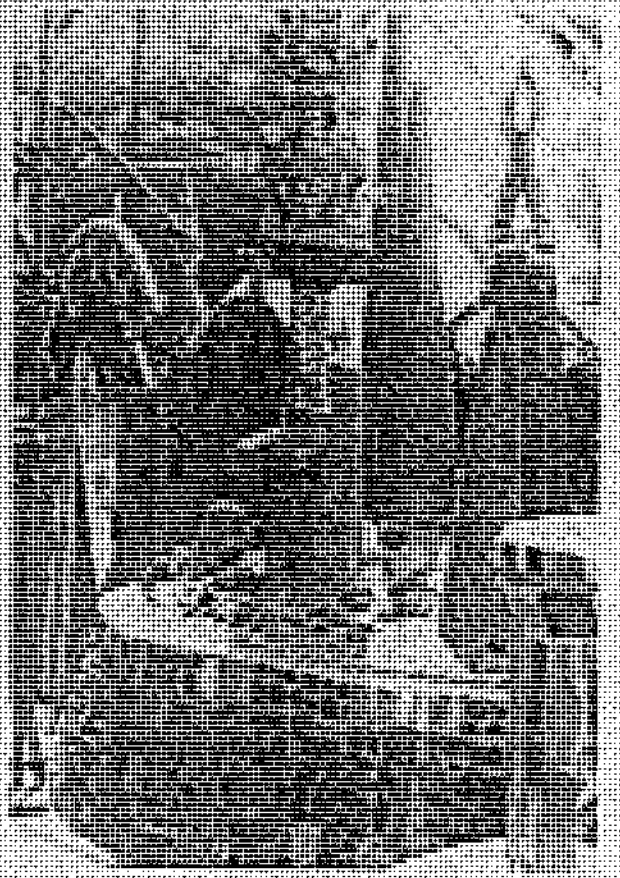


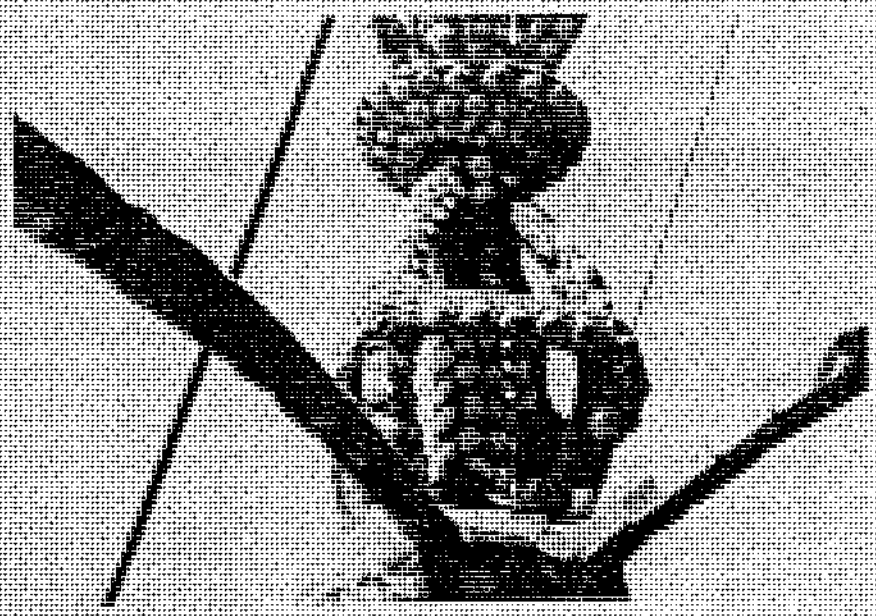


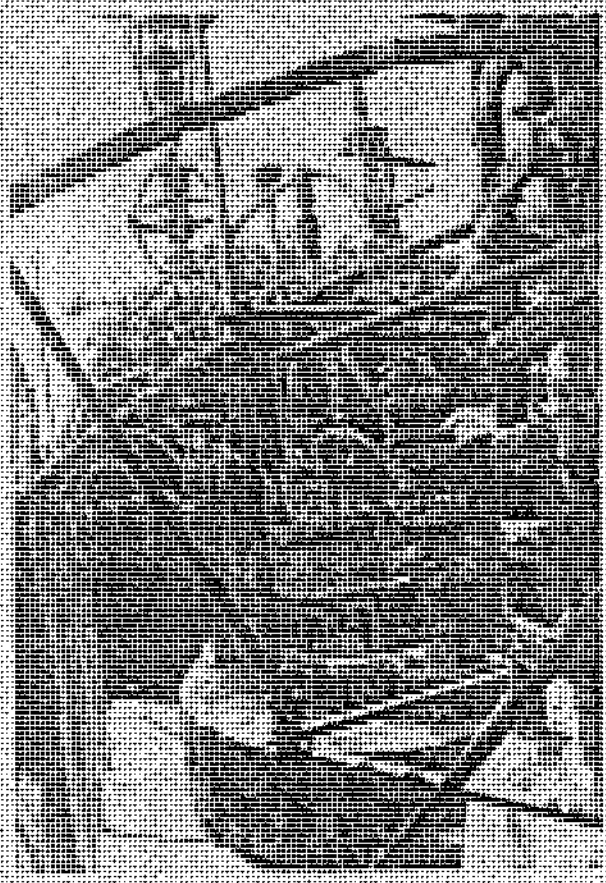












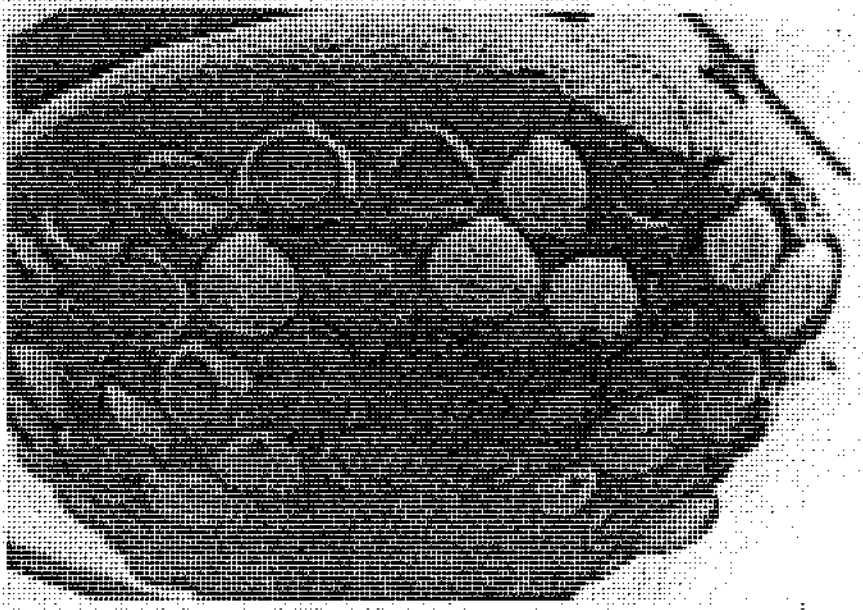


Figure 70 Detail of basket construction on ship. Dark area in center is corroded metal bowl armature. Note cracking and loss of ornament.

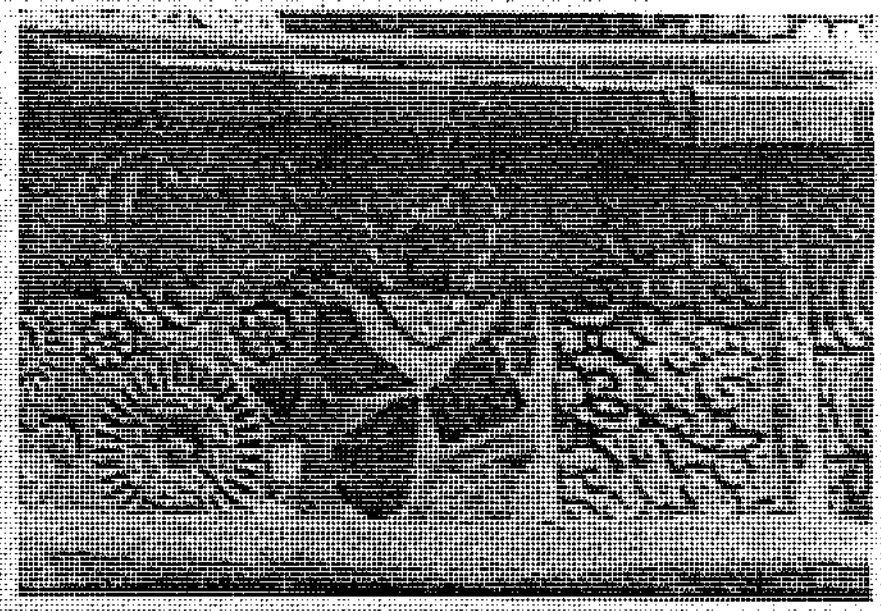
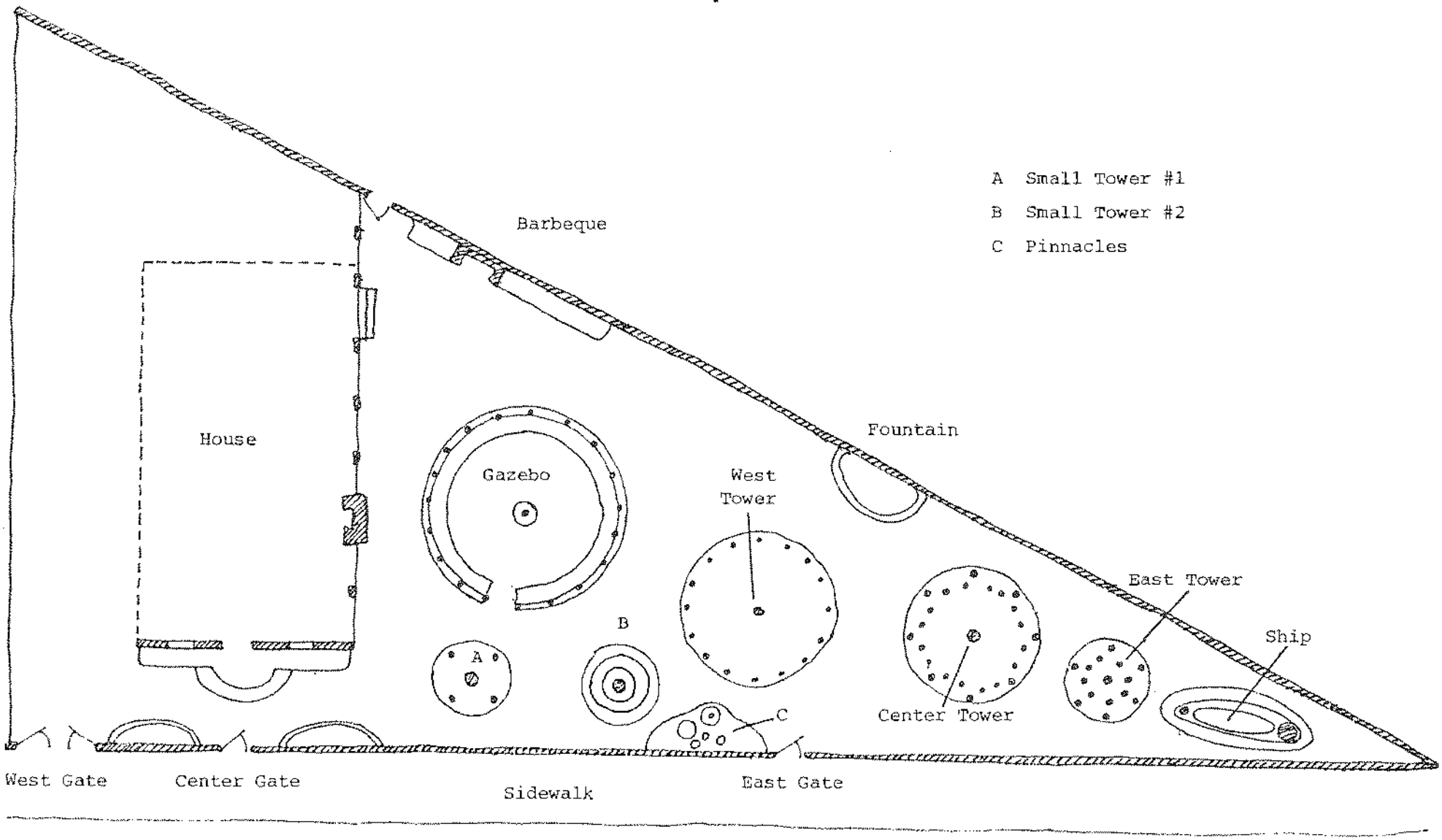


Figure 71 Detail of top level of base on ship.



SITE PLAN

SIMON RODIA'S TOWERS IN WATTS

THE EHRENKRANTZ GROUP

AUGUST 1982

Figure 72

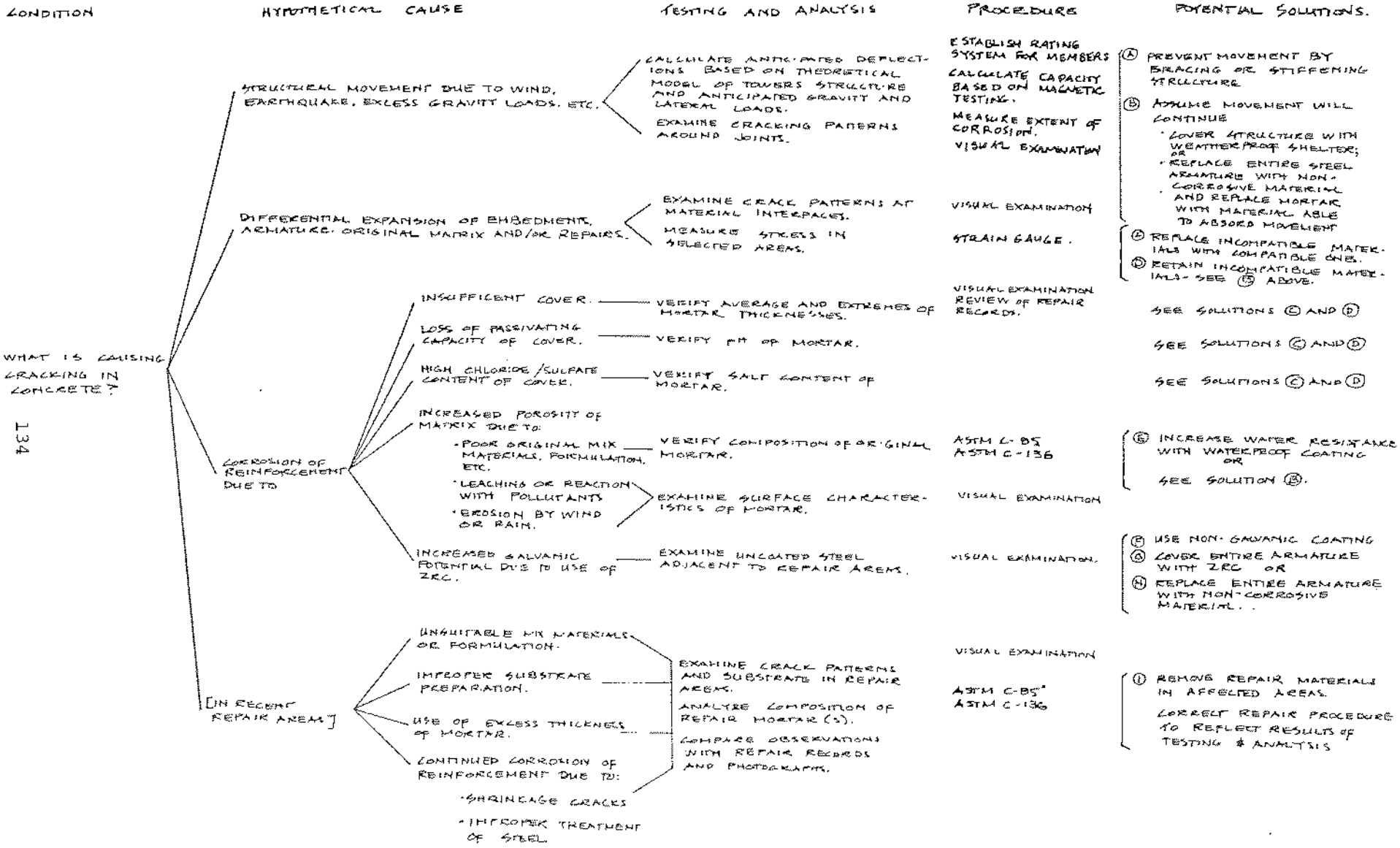

CONDITION
HYPOTHETICAL CAUSE
TESTING AND ANALYSIS
PROCEDURE
POTENTIAL SOLUTIONS.
WHAT IS CAUSING CRACKING IN CONCRETE?
STRUCTURAL MOVEMENT DUE TO WIND, EARTHQUAKE, EXCESS GRAVITY LOADS, ETC.
CALCULATE ANTICIPATED DEFLECTIONS BASED ON THEORETICAL MODEL OF TOWERS STRUCTURE AND ANTICIPATED GRAVITY AND LATERAL LOADS.
EXAMINE CRACKING PATTERNS AROUND JOINTS.
ESTABLISH RATING SYSTEM FOR MEMBERS
CALCULATE CAPACITY BASED ON MAGNETIC TESTING.
MEASURE EXTENT OF CORROSION.
VISUAL EXAMINATION
(A) PREVENT MOVEMENT BY BRACING OR STIFFENING STRUCTURE
(B) ASSUME MOVEMENT WILL CONTINUE
• COVER STRUCTURE WITH WEATHERPROOF SHELTER; OR
• REPLACE ENTIRE STEEL ARMATURE WITH NON-CORROSIVE MATERIAL AND REPLACE MORTAR WITH MATERIAL ABLE TO ABSORB MOVEMENT
DIFFERENTIAL EXPANSION OF EMBEDMENTS, ARMATURE, ORIGINAL MATRIX AND/OR REPAIRS.
EXAMINE CRACK PATTERNS AT MATERIAL INTERFACES.
MEASURE STRESS IN SELECTED AREAS.
VISUAL EXAMINATION
STRAIN GAUGE.
(C) REPLACE INCOMPATIBLE MATERIALS WITH COMPATIBLE ONES.
(D) RETAIN INCOMPATIBLE MATERIALS - SEE (B) ABOVE.
CORROSION OF REINFORCEMENT DUE TO
INSUFFICIENT COVER.
VERIFY AVERAGE AND EXTREMES OF MORTAR THICKNESSES.
VISUAL EXAMINATION
REVIEW OF REPAIR RECORDS.
SEE SOLUTIONS (C) AND (D)
LOSS OF PASSIVATING CAPACITY OF COVER.
VERIFY PH OF MORTAR.
SEE SOLUTIONS (C) AND (D)
HIGH CHLORIDE/SULFATE CONTENT OF COVER.
VERIFY SALT CONTENT OF MORTAR.
SEE SOLUTIONS (C) AND (D)
INCREASED POROSITY OF MATRIX DUE TO:
• POOR ORIGINAL MIX MATERIALS, FORMULATION, ETC.
VERIFY COMPOSITION OF ORIGINAL MORTAR.
ASTM C-85
ASTM C-136
(E) INCREASE WATER RESISTANCE WITH WATERPROOF COATING OR
SEE SOLUTION (B).
• LEACHING OR REACTION WITH POLLUTANTS
• EROSION BY WIND OR RAIN.
EXAMINE SURFACE CHARACTERISTICS OF MORTAR.
VISUAL EXAMINATION
INCREASED GALVANIC POTENTIAL DUE TO USE OF ZINC.
EXAMINE UNCOATED STEEL ADJACENT TO REPAIR AREAS.
VISUAL EXAMINATION.
(F) USE NON-GALVANIC COATING
(G) COVER ENTIRE ARMATURE WITH ZINC OR
(H) REPLACE ENTIRE ARMATURE WITH NON-CORROSIVE MATERIAL.
[IN RECENT REPAIR AREAS]
UNSUITABLE MIX MATERIALS OR FORMULATION.
IMPROPER SUBSTRATE PREPARATION.
USE OF EXCESS THICKNESS OF MORTAR.
CONTINUED CORROSION OF REINFORCEMENT DUE TO:
• SHRINKAGE CRACKS
• IMPROPER TREATMENT OF STEEL
EXAMINE CRACK PATTERNS AND SUBSTRATE IN REPAIR AREAS.
ANALYZE COMPOSITION OF REPAIR MORTAR (S).
COMPARE OBSERVATIONS WITH REPAIR RECORDS AND PHOTOGRAPHS.
VISUAL EXAMINATION
ASTM C-85
ASTM C-136
(I) REMOVE REPAIR MATERIALS IN AFFECTED AREAS.
CORRECT REPAIR PROCEDURE TO REFLECT RESULTS OF TESTING & ANALYSIS

Figure 73

E. CONDITION SURVEY, TESTING, AND ANALYSIS APPENDICES

STATE OF CALIFORNIA—THE RESOURCES AGENCY EDMUND G. BROWN JR., Governor

DEPARTMENT OF PARKS AND RECREATION
P.O. BOX 2390
SACRAMENTO 95811
(916) 445-3130

November 24, 1982

Mr. Andrew Rabenech, Director
The Ehrenkrantz Group
140 Chestnut Street
San Francisco, CA 94111

Dear Andrew:

The preparation of the Watts Towers Preservation Plan has progressed to a point where the final plan will soon be completed. However, the Phase I and II meetings have left unresolved the problem of seismic impact on the Towers. Any decisions to mitigate the seismic hazard, as well as to preserve the historic fabric and repair present deterioration, must consider that all these actions are interrelated. We believe that a decision must be made as to how to consider the eventuality of an earthquake, and we have discussed this problem with the Board of Directors of the Committee for Simon Rodia's Towers in Watts.

The Phase II Report states that "the structural integrity of the Towers, under seismic or extreme winds, depends upon the continuity of space framework...." The current Watts Towers repair methodology places a high priority on salvaging and replacing both the stucco and ornamentation. According to your structural consultant, this methodology, should it be continued, would remove a "probable randomness of the joinery and replace the present tower structure with an assemblage of finite length members". This would highly increase the probability of physical separation of the stucco pieces due to tensile loads caused by lateral forces of wind and earthquake. However, the possibility of damage to the fabric due to extreme wind loads is very small in the L.A. area, according to the structural consultant.

The possibility of an earthquake is much more real. The Phase II Report states that damage to the Watts Towers due to an earthquake of design intensity and less than design intensity becomes highly probable if the life of the structure is extended 50 to 80 years as we want the life expectancy to be. Mitigation of the damage potential posed by earthquakes is difficult to impractical if the brittle stucco coating is retained, nevertheless, the probability of collapse or complete loss of vertical load carrying capacity of the vertical supports element is small, according to the structural consultant. To limit damage, the consultant recommends repair techniques that restore the original or improve the continuity of the Towers. But to achieve this, your consultant estimates that an additional 50% of the historic fabric must be removed during the repair process. This may reduce the loss of fabric during an earthquake of design intensity by 5 or 10%. If this work is not done, the loss to the Watts Towers may be over 65%.

We are very concerned about the life-safety hazard posed by earthquakes, especially if the present repair methodology is not changed. The structural consultant has stated that the possibility of total collapse of the Towers is small and that the life-safety threat will be the separation of parts of the mortar covering from the armature. The Phase II report states that "procedures such as access control, protective screens, or headgear may reduce the life-safety threat to a level acceptable to a viewer and the operating agency". This is the approach we want to take.

Our decision is to preserve as much as possible of Simon Rodia's work, while providing a reasonable level of structural safety for the occupants and the public at large without planning for a design intensity earthquake. To attempt to secure the Towers against the possibility of an earthquake of design intensity will mean the substantial loss of the very fabric we want to preserve. Although the additional work may reduce the earthquake loss, there are no guarantees. Further, the work will be an additional expense for an already small budget. We want the Preservation Plan to be prepared according to the above decision, making the necessary adjustments to the recommended repair methodology and maintenance program. If replacement of the armature in critical members is needed, the work should be designed to bring the members and joints up to the original strength and appearance, reapplying only the ornamentation. In other less critical members, the original stucco coating and ornamentation should be replaced if at all possible. The original construction methodology should be matched as closely as possible. All repairs should match the original appearance and fabric as to texture, color, size, and ornamentation.

If you want to discuss the above matter, please feel free to contact me.

Sincerely,

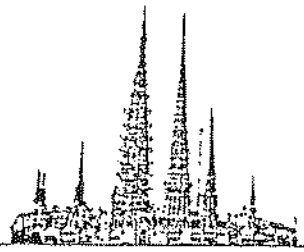
Earl V. Carlson, Supervisor
Architectural Section

J-1287L

cc: Ms. Jill Dolan
Mr. Rodney Punt
Mr. Bud Goldstone
Mr. Jerry Stanley

October 13, 1982

FOR IMMEDIATE RELEASE



The Committee for Simon Rodia's Towers in Watts

The Board of Directors acting on and in behalf of The Committee For Simon Rodia's Towers in Watts, has reached the following conclusions after extensive discussions with Earl Carlson, Steade Craigo, and Bill Huser and after a review of the Phase I and Phase II reports of The Ehrenkrantz Group of San Francisco, California:

1. The Board recommends to the State of California and to its contracted agent, The Ehrenkrantz Group, that:

   a. Given that the extent and cost of structural repairs required to properly reinforce the structures against a design event disturbance earthquake would, of necessity, include a thorough removal and subsequent replication of a large portion of the structure and its fabric, the Board finds that it is unable to recommend an approach for preservation which would be aimed at securing that end. Therefore:

   b. It is the opinion of the Board that a "middle ground" approach to preservation should be taken which would be defined as to, in general, maintain as much of the original fabric of Simon Rodia as is feasible and, in those areas where corrosion requires replacement of structural core and reapplication of mortar and ornamentation, that this be done in such a way to provide an increased structural capacity with limited visual distraction. It has been noted by The Ehrenkrantz Group and their engineering consultants that the thickness of the mortar covering is in many locations inadequate to prevent future corrosion and spalling of mortar and, therefore, where possible, the thickness of the mortar covering and the extent of overlap of the original core structural steel members and newly inserted replacement members should be increased. The CSRTW recommends repair work which would implement such recommendations

   c. Consistent with the views expressed in items a and b, where structural repairs require that fabric be removed, new mortar covering and applied ornamentation shall replicate as closely as possible the original appearance of the work of Simon Rodia in color, texture, and design.

(Cont.)

Post Office Box 1461 Los Angeles, California 90028

2. In view of the concerns and interests expressed above, The CSRTW will continue its exploration of the feasibility and ramifications of installation of a permanent, independently-structured, weatherproof enclosure for the entire property.

Resolution: The Board has resolved to issue a letter stating its recommendations in writing and that these recommendations were communicated verbally on the above date to Earl Carlson, Steade Craigo, and Bill Muser of the State of California Department of Parks and Recreation at the conclusion of a meeting attended by them and The CSRTW Board of Directors.

CLIENT EHRENKRANTZ

KARIOTIS & ASSOCIATES
STRUCTURAL ENGINEERS

SHT. OF

BY NELS

SUBJECT: WATTS TOWERS

DATE 9-22-82

ITEM INDEX TO STRUCTURAL CALCULATION APPENDIX

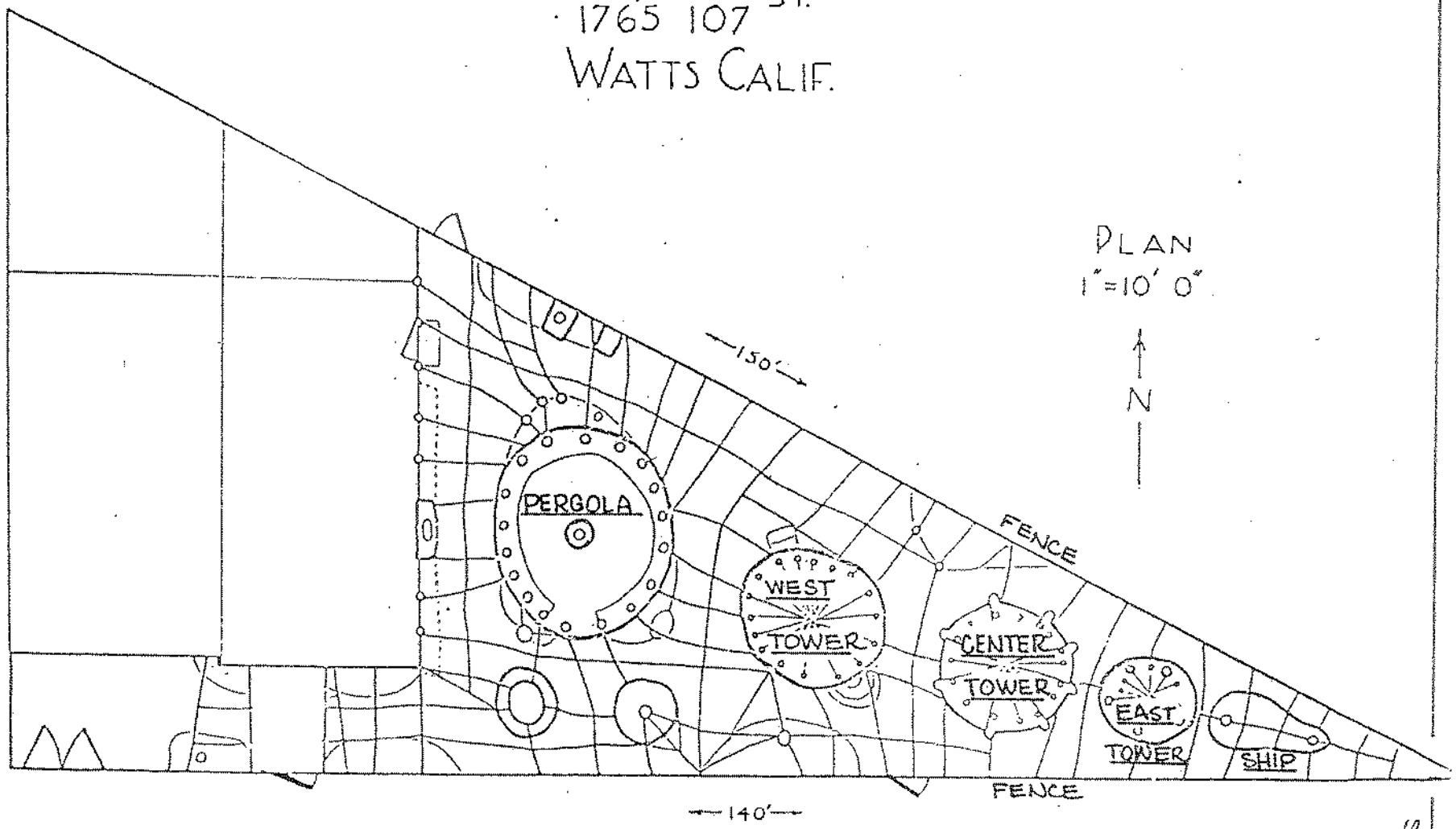
JOB NO. 82-104

TOWER SITE PLAN		A1
TOWER PARTS IDENTIFICATION		B1
WEST TOWER -	ESTIMATE WEIGHT	C1 THRU C3
	ESTIMATE PERIOD & RESPONSE	C4 THRU C6
	SKETCH OF STRUCTURAL CONFIGURATION	C7
	INVESTIGATE LOAD RESISTING MECHANISMS	C8 THRU C16
	LOAD-DEFLECTION PLOT FOR VARIABLE FLEXIBILITY MODEL OF WEST TOWER	C17.
CENTER TOWER -	ESTIMATE WEIGHT	D1
	SKETCH OF STRUCTURAL CONFIGURATION	D2
	INVESTIGATE LOAD RESISTING MECHANISMS	D2 THRU D3

SIMON RODIA'S TOWERS

1765 107 ST.

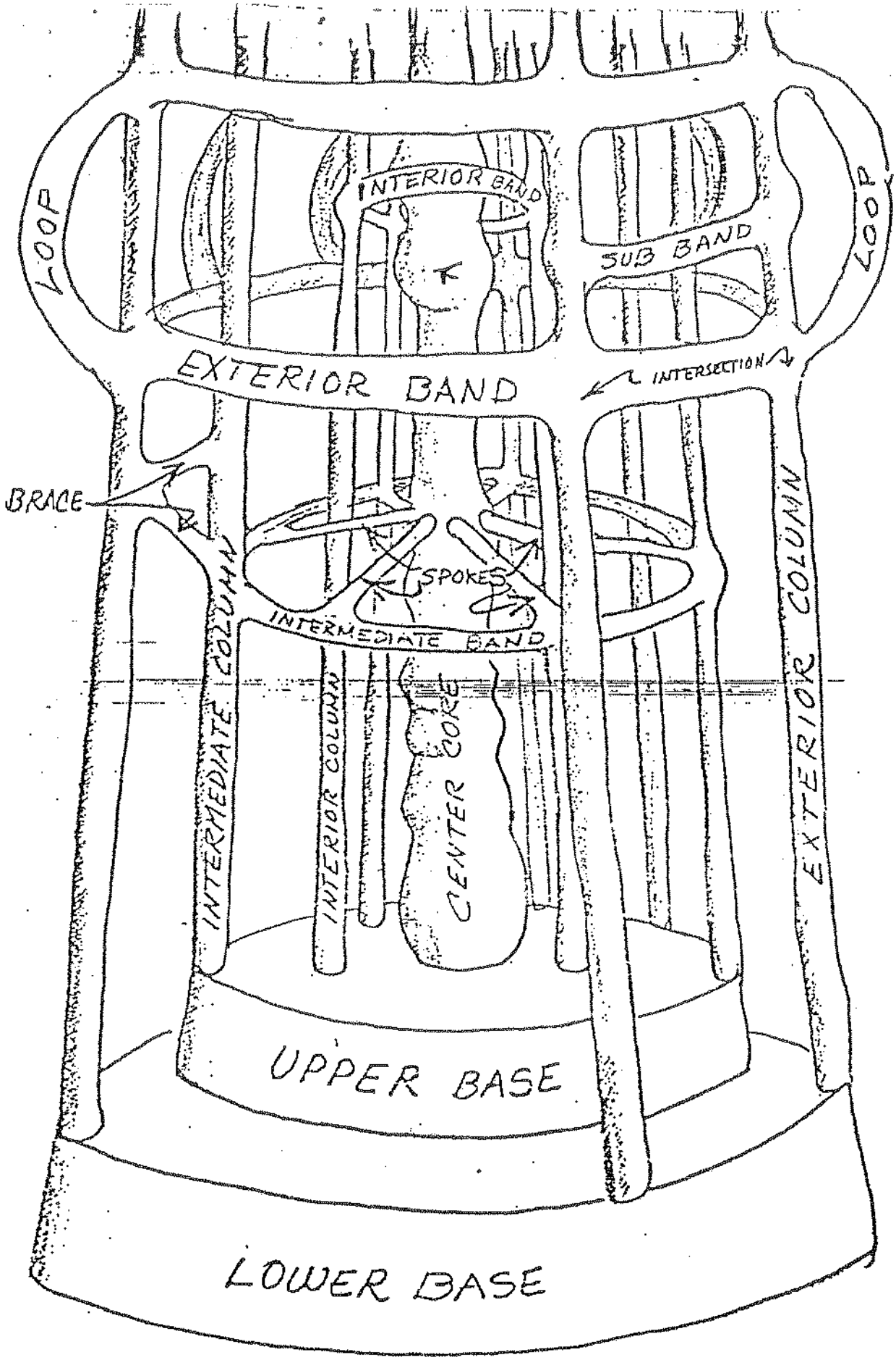
WATTS CALIF.



107TH ST.

SHEET A-1

140



TOWER PARTS IDENTIFICATION (TYPICAL)

CLIENT EHRENKRANTZ

KARIOTIS & ASSOCIATES
STRUCTURAL ENGINEERS

SHT. C1 OF

BY NELS

PROJECT: WATTS TOWERS

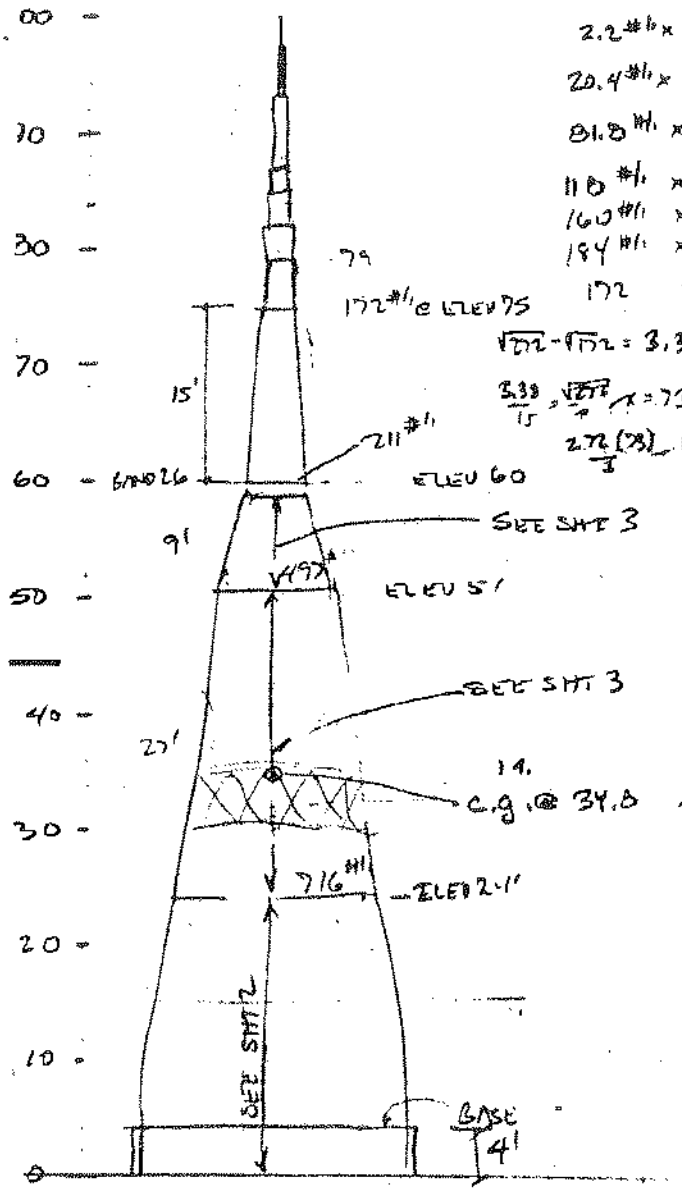
DATE 8-5-92

TITLE WEST TOWER (C)

JOB NO. 92-104

ESTIMATE WEIGHT - @150#/CU.FT. CONC.

24,000#



	WT	HT	
2.2#/' x 2.6	6#	98.6	
20.4#/' x 4.1	84#	95.4	
81.8#/' x 6.3	518#	90.2'	
118#/' x 2.0	236#	86.0'	
160#/' x 3.0	480#	83.5'	
184#/' x 3.0	552	80.5'	209#/'
172 x 4.0	688	77.0'	

$\sqrt{272} - \sqrt{172} = 3.38$

$\frac{3.38}{15} = \frac{\sqrt{272}}{x} \quad x = 73'$

$\frac{2.72(73)}{3} - \frac{172(73-15)}{3} =$

	3293#	63.8'	
	(5860#)	(72.26)	ABOVE EL 60
8847	3090#	54.85	ELEV 51 TO EL 60
	14,910	33.66'	
	13,650		ELEV 0 TO ELEV 24
	37,620#		ΣWT x HT: 1,309,200

WT ABOVE C.G.:
5860
3080
10570 ← SHT C3
19510 - ABOUT 1/2

HT TO C.G. $\frac{\Sigma WT \times HT}{\Sigma WT} = 34.7'$

TOTAL WT OF CENTER COL & TRIBUTARY MEMBERS 3,920

33,700# CARRIED ON 16 COLS: 2110#/COL

USE Rayleigh FORMULA TO ESTIMATE PERIOD USING GOLDSTONE TEST DEFL'S & OUR ~~LUMPED~~ WEIGHTS LUMPED. - SEE SHT C5

CLIENT EHRENKRANTZ

KARIOTIS & ASSOCIATES
STRUCTURAL ENGINEERS

SHT C2 OF

BY NELS

SUBJECT: WATTS TOWER

DATE 8-5-82

ITEM WEST TOWER (C)

JOB NO. 82-103

ESTIMATE WEIGHT

ITEM	WEIGHT		HEIGHT	CENTER CORE WEIGHT
CENTER CORE EL 17'-6 TO EL 24 156#/' x 6.5	1014		20.7	1014
BAND 10	280#		24	
BAND 9 PLUS BLOPS 186 BAND + 480 BLOPS	666		22.5	
BAND 8	316#		21.5	
BAND 7	438#		19.5'	
OUTER LOOPS & SUPERBAND @ BAND 7 (LOOP 6 TO 9) 623# + 292	919#		19.5'	
INNER LOOPS & CENTER CORE EL 13'-8 TO EL 17'-6 (17 + 25 x 1.5) 3.83 + 320 (COLS LOOPS)	528#		15.6'	—
STRAIGHT SPOKES & INNER BAND @ BAND 7	420#		20.0	210
COLUMN BLOBS @ BAND 5:	300#		15.5	
BAND 6A & ARCHES ADJ SHORT COLUMNS 100 + 150 + 142	392#	14665	15.8	
BAND 6 PLUS BLOPS 266 + 320	586#		17.5'	
BAND 5 PLUS BLOBS 500 + 300	800#		15.5	
COLS, BAND 4 TO BAND 10 154#/' (11.5)	1770		18.2	
ARCHED SPOKES & INNER BAND NEAR BAND 5	1097		11.8'	5[illegible]
CAPITAL @ CORE - @ ARCHED SPOKES	565		12.8	565
CENTER CORE BASE TO EL 11.84 140#/' AVG (4.6')	645		9.5	64[illegible]
BAND 4	197		12.5	
COLS BAND 3-4	354		11.6	
BAND 3	402		10.8	
COL'S BAND 2-3	560#		10.6	
BAND 2	141#		9.8	
COL'S @ BAND 1 TO BAND 2 $\frac{202+219}{2}$ (1.5)	316#		9.1	
BAND 1 EL 8.33	319#		8.3	
COLUMNS, BASE TO BAND 1 $\frac{240+202}{2}$ (4.8)	906 = 1840#		6.1	—

1365'

CLIENT EHRENKRANTZ

KARIOTIS & ASSOCIATES
STRUCTURAL ENGINEERS

SHT. C3 OF

BY DELS

SUBJECT: WATTS TOWER

DATE 8-6-82

ITEM WEST TOWER (C)

JOB NO. 82-104

ESTIMATE WEIGHT

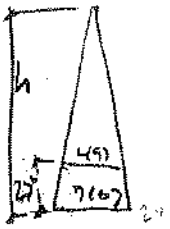
ESTIMATE AVG WT/FT @ BAND 10 ELEV 24

			CENTER COLUMN WEIGHT
CENTER COLUMN	156#/'		156#/'
OUTER COLS	154#/'		
BANDS	186#/'	280#/'/1.5' o.c.	
LOOPS	183#/'	919#/5 FT o.c.	
SPOKES	37#/'	333#/9' o.c.	165#/'
	716#/' @ BAND 10		
			(321#/')

ESTIMATE AVG. WT. @ BAND 20 ELEV 51

BANDS	98#/'	197#/2'	
CENTER COL	80#/'	60#/' COL + 20#/' INNER LOOPS & BANDS	80#/'
OUTER COL'S	117#/'		
LOOPS	104#/'		
BANDS ON LOOPS	28#/'	167#/6'	
SPOKES	20#/'		10#/'
BLOBS ON COLS	50#/'		
	497#/' @ BAND 20 - ELEV 51		(90#/')

ESTIMATE WT ELEV 24 TO ELEV 51



$\sqrt{716} = 26.8$

$\sqrt{497} = 22.3$

4.5

$\frac{4.5}{27} = \frac{26.8}{h}$ $h = 143'$

@ EL 35 $\frac{4.5}{27} = \frac{x}{11}$ $x = \frac{26.8}{1.83}$ 25.0

$25^2 = 625$#/' @ ELEV 35

WT EL 35 TO 51: $\frac{625 \times 143}{3} - 19217 = 10,570$#

$\sqrt{321} = 17.92$

$\sqrt{90} = 9.49$

8.43

$W_T = \frac{716(143)}{3} - \frac{497(143-27)}{3} = 14,910$# @ $\frac{\frac{34129(143')}{4} - 19217\left[\left(\frac{143-27}{4}\right)+27\right]}{14910} = 9.66'$ (EL 24+9.66 = 33.66 FEET)

34,129 19,217

ESTIMATE WT ELEV 51 TO ELEV 60

$\sqrt{211} = 14.5$

$\sqrt{497} = 22.3$

7.8

$\frac{7.8}{9'} = \frac{22.3}{h}$ $h = 25.7'$

$\frac{\frac{4257.6(25.7)}{4} - 1174.6\left[\left(\frac{25.7-9}{4}\right)+9\right]}{3083} = 3.8$ FT

$W_T = \frac{497(25.7)}{3} - \frac{211(25.7-9)}{3} = 3083$ @ 3.85' TO C.G. EL = 51+3.85 = 54.85'

4257.6 1174.6

CLIENT EHRENKRANTZ GROUP

KARIOTIS & ASSOCIATES
STRUCTURAL ENGINEERS

SHT. 64 OF
BY DELS
DATE 8-16-82
JOB NO. 82-105

SUBJECT: WATTS TOWERS

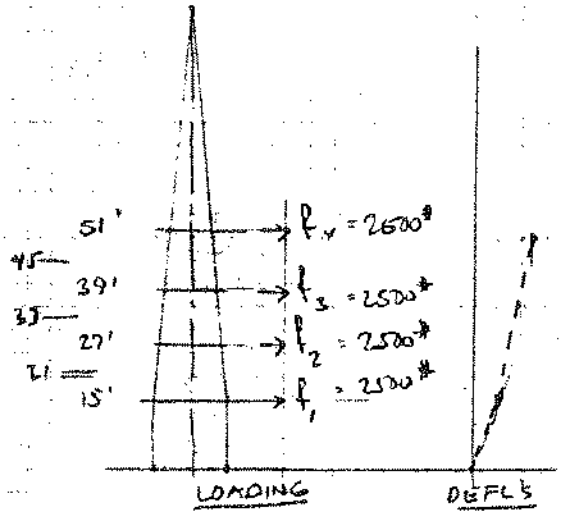
ITEM

WEST TOWER C

PERIOD OF TOWER

BASIS 1. USE FORMULA 12.3 OF UBC & RESULTS OF
2. TEST BY N.J. GOLDSTONE : 1954 LOAD TEST
ASSUME WT OF TOWER IS LUMPED @ 2 POINTS @ WHICH GOLDSTONE PROVIDES LOAD/DEFL DATA.

ELEV



$f_1 = f_2 = f_3 = f_4 = \frac{10{,}000}{4} = 2500^{\#}$

$\Delta_4 = 1\ 9/16$

$\Delta_1 = 1/2"$

WT OF TOWER ABOVE EL 51': 8940#
WT " " BELOW EL 51': 29560#
WT OF TOWER BELOW EL 15': 6240#
" " " BET EL 15 & 51 : 22,320#

WT OF TOWER/FT @ EL 51: $497^{\#/'}$
WT OF TOWER/FT @ EL 15: $\frac{w_{15}(h+36)}{3} - \frac{497(h)}{3} = 22{,}320$

$\sqrt{w}_{15}$

ASSUME f_3 & f_4 ARE APPLIED @ EL 51 : 5000#
f_1 & f_2 " " " EL 15 : 5000#

CALCULATE WT OF TOWER/FT @ ELEV IS

$1990\left(\frac{89.62}{3}\right) - 497\left(\frac{89.62}{3}\right)$

$\frac{w_{15}(h+36)}{3} - \frac{497(h)}{3} = 22{,}320^{\#}$

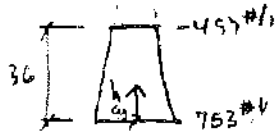
$\frac{\sqrt{w} - \sqrt{497}}{36'} = \frac{\sqrt{w}}{36+h}$

SOLVE SIMULTANEOUS EQUATIONS

$wh + 36w - 497h = 66960$ $\quad w = \frac{66960 + 497h}{h+36}$

$\sqrt{w}(36) + \sqrt{w}(h) = 802 - 22.29h = 36\sqrt{w}$ $\quad h = \frac{802}{\sqrt{w} - 22.29}$

$h = 155.7$
$w = 753^{\#/'}$



WT OF IMAGINARY CONE ABOVE : $\frac{497(155.7)}{3} = 25794$

LOCATE C.G: $h_{c.g.} = \frac{(22{,}320 + 25794)(155.7 + 36) - 25794\left(\frac{155.7}{4} + 36\right)}{22{,}320}$

$= 16.7'$

CLIENT Ehrenkrantz Group — KARIOTIS & ASSOCIATES, STRUCTURAL ENGINEERS — SHT 5 OF

BY DLS

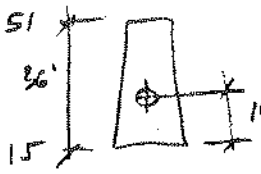
SUBJECT: Watts Tower — DATE 8-16-82

ITEM — JOB NO. 8210'

West Tower C

Period of Tower

Tributary portions of tower bet El 15 & El 51 to those elev's



Eff. trib to elev 51: $\frac{22\,320(16.7)}{36}$ = 10,350#

Eff. trib to elev 15: 11,970#

Eff wt @ elev 51: 8940 + 10350 = 19,290#

Eff wt @ elev 15: 6240 + 11970 = 18,210#

37,500#

Period on basis of Rayleigh Formula;

$$T = 2\pi\sqrt{\frac{19290\,(1.1875)^2 + 18210\,(.5)^2}{[5000(1.1875) + 5000(.5)]\,386}} = 2\pi\sqrt{\frac{3754}{325,605}}$$

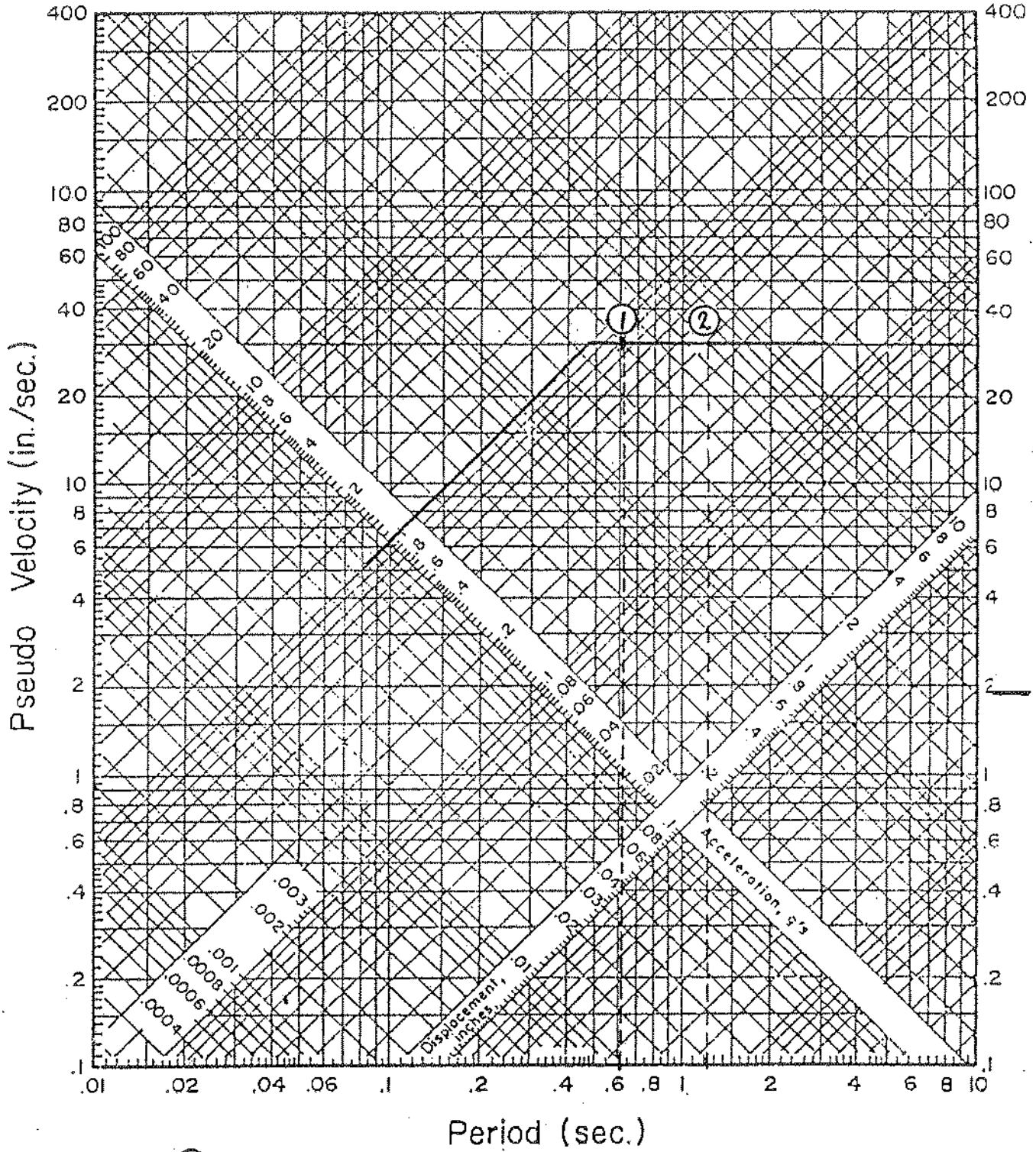
= 0.620 sec = period of equivalent mass oscillator

w/ greater displacements, microcracking will reduce stiffness, increasing period.

WATTS TOWERS

WEST TOWER (C) ESTIMATE RESPONSE.

SHT C6



(1) MAXIMUM RESPONSE OF TOWER WITH PERIOD BASED ON 1959 LOAD TEST D. A.

(2) MAXIMUM RESPONSE OF TOWER WITH PERIOD TWICE (1) AS MAY RESULT FROM PROGRESSIVE MICROCRACKING DUE TO DISPLACEMENT GREATER THAN TEST LOAD DISPLACEMENT.

Kariotis & Associates

CLIENT EHRENKRANTZ

KARIOTIS & ASSOCIATES
STRUCTURAL ENGINEERS

SHT. C 7 OF

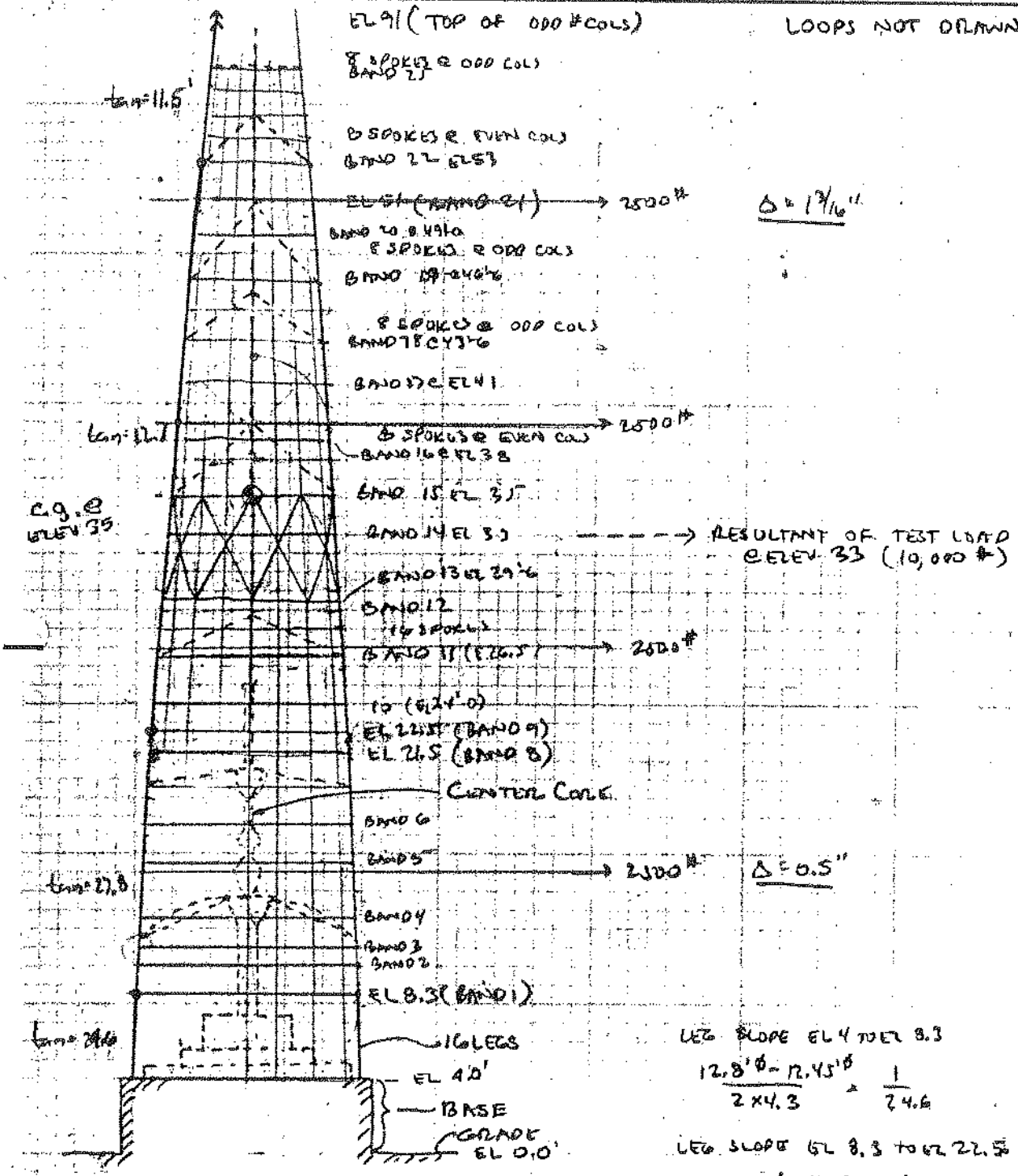
BY NELS

SUBJECT: GIANTS TOWERS

DATE 8-17-82

ITEM WEST TOWER (C) - CONFIGURATION SKETCH

JOB NO. 82-104



ALL LEG SLOPES

LEG SLOPE EL 4 TO EL 8.3

$$\frac{12.8' \phi - 12.45' \phi}{2 \times 4.3} = \frac{1}{24.6}$$

LEG SLOPE EL 8.3 TO EL 22.5

$$\frac{12.45' - 11.43}{2 \times 14.2} = \frac{1}{27.8}$$

LEG SLOPE EL 22'6 TO EL 53

$$\frac{11.43 - 6.61}{2 \times 30.5} = \frac{1}{12.7}$$

LEG SLOPE EL 53 TO TOP OF COLUMN EL 91

$$\frac{6.61}{2 \times 38} = \frac{1}{11.5}$$

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STRUCTURAL ENGINEERS

SHT 68 OF

BY NELS

SUBJECT: WATTS TOWERS

DATE 8-17-82

ITEM (WEST TOWER (C)

JOB NO. 82-104

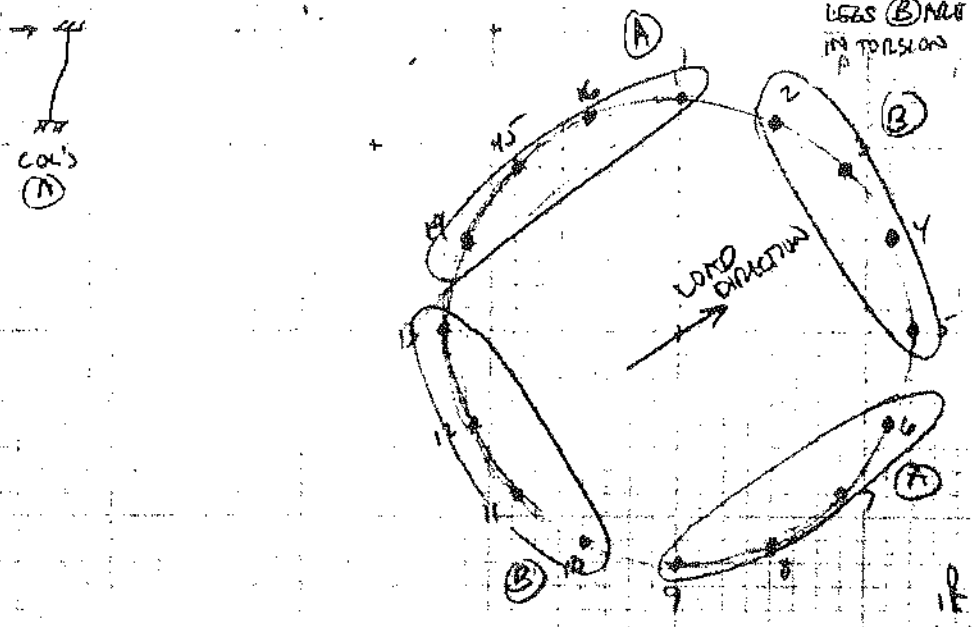
INVESTIGATE MECHANISM FOR EXISTING TEST LOAD

TEST LOAD 10,000# (BY GOLDSMITH)

M_{OT} @ TOP OF BASE (EL 4.2') = 10,000 (33 - 4.1') = 290,000 l#

Σ AREA OF LEGS @ BASE 229 in^2 $A_{AVG} = \frac{229}{16} = 14.3\ in^2$ $d_{AVG} = \sqrt{\frac{4 \times 14.3}{\pi}} = 4.3\ in$ $S = 7.6\ in^3$ $I = 16.3\ in^4$

1. IN ZONE FROM BASE TO BAND 1, IF LEGS 16 LEGS CARRY LOAD IN FRAME ACTION (NO SHEAR OR CANTILEVER), LEGS (A) ARE FIXED TOP & BOTTOM BY BASE & BAND IN BEND. LEGS (B) ARE FIXED @ BOTT. BY BASE, @ TOP BY B & IN TORSION



$f_{AV} = \frac{10,000}{229\ in^2} = 43.7\ \#/in^2$

LOAD/COL: $\frac{10,000}{16} = 625\#$

$M = \frac{625(4')}{2} = 1250\ l\#/col$

$f_b = \frac{1250(12)}{7.6} = 1973\ \#/in$

VERY HIGH

THIS ALONE IS UNLIKELY MECHANISM FOR LOAD PATH

axial stress based on vertical dead load: $\frac{33700}{229} = 147\ \#/in^2$

If tensile strength of mortar is taken as $600\ \#/in^2$ total load capacity for this load path is:

$V_A = 10,000\left(\frac{600 + 147}{1973}\right) = 3840\#$

$\Delta = \frac{\frac{3840}{16}\left(\frac{4}{2}\right)^3(1728)}{3 \times 2 \times 10^6 \times 16.3} \times 2 = .067$

SEE EXHIBIT C14 FOR STRESS & Δ BASED ON INCLUSION OF ALUMINUM

2. IF O.T.M IS CARRIED BY AXIAL TENSION & COMPRESSION IN LEGS, IT IS REASONABLE TO ASSUME EACH LEG CARRIES LOAD ON BASIS OF ~~ITS POSITION~~ ITS POSITION ONLY INDEPENDENT OF ITS CROSS-SECTIONAL AREA @ ANY PARTICULAR ELEVATION - (THE CROSS SECTION AREAS OF THE LEGS VARIES VERTICALLY AS WELL AS AROUND THE TOWER)

CLIENT EHRENKRANTZ

KARIOTIS & ASSOCIATES
STRUCTURAL ENGINEERS

SHT. C9 OF

BY DCK

SUBJECT: WATTS TOWERS

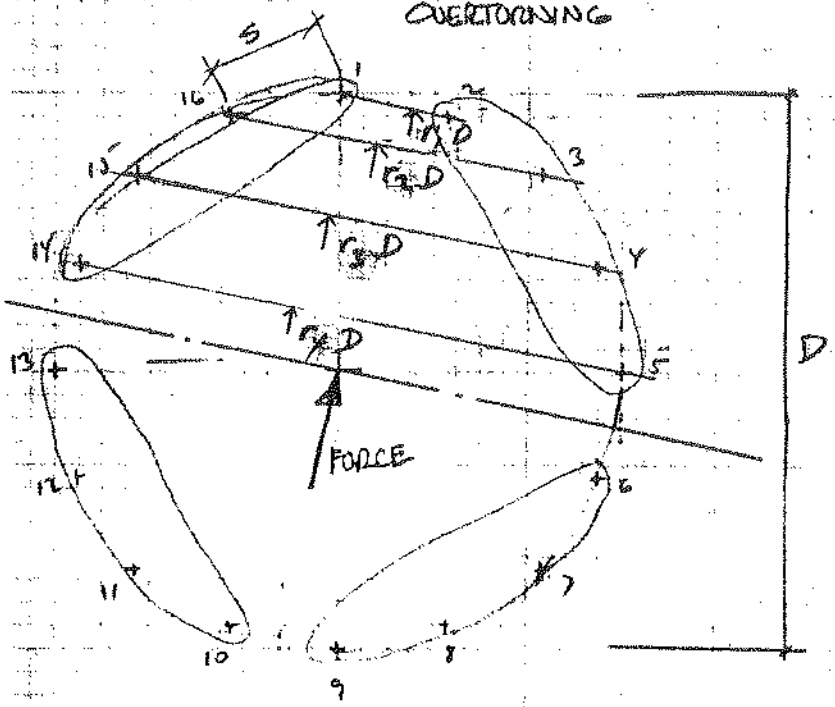
DATE 8-17-82

ITEM WEST TOWER (C)

JOB NO. 82-104

INVESTIGATE MECHANISM FOR RESISTING TEST LOAD

OVERTURNING



BASIS — LEGS @ EQUAL SPACING & RU w/ EQUAL SLOPE

$D = \frac{C}{\pi}$

$s \simeq \frac{C}{16}$

		rD	r^2
r_1	$\frac{D}{2}(\cos 11.25°) = .490D$	.24	
r_2	$\frac{D}{2}(\cos 33.75°) = .420D$	.17	
r_3	$\frac{D}{2}\cos(56.25°) = .280D$	.08	
r_4	$\frac{D}{2}\cos(78.25°) = .100D$	.01	
		.50	

FORCE IN LEG = $\frac{M \times r^2}{2rD}$

@ BASE, D ≈ 13'
M = 2900 IK

5918 x 2 x 11.26 = 139,190

4890 x 2 x 10.1 = 98,378

3452 x 2 x 6.62 = 46,400

LEG 1 & 2 (9 & 12): $P = \frac{290{,}000(.24)}{2x.49x13} = \pm 5.46^{IK}$; $\Sigma M = 5.46 \times 2 \times 13 \times .49 \times 2 = 139^{IK}$ (JUST @ BASE)

$\frac{P}{A} = \frac{5.46}{14.3} = \pm 380^{\#/in^2}$ IN UNCRACKED SECTION (JUST CLO) + 147 #/in² AL. CAGE

LEG 3 & 16 (8 & 11): $P = \frac{290(.17)}{2x.42x13} = 4.51^{K}$; $\Sigma M = 4.51(2)(13)(.42)(2) = 99^{IK}$

LEG 4 & 15 (7 & 12): $P = \frac{290(.08)}{2x.28x13} = 3.19^{K}$; $\Sigma M = 3.19 \times 2 \times 13 \times .28 \times 2 = 46^{IK}$

LEG 5 & 14 (6 & 13): $P = \frac{290(.01)}{2x.10x13} = \frac{1.12^{K}}{14.28}$; $\Sigma M = 1.12 \times 2 \times 13 \times .10 \times 2 = \frac{6^{IK}}{290^{IK}}$ CHECK

NET AXIAL LOAD: 5460 + 2110 = 7570# COMPRESSION

−5460 + 2110 = −3350# TENSION

SMALLEST COL: 3½" / 4½" — 7.89 in²

HORIZ. COMPONENT OF O.T. FORCE: $\Sigma\left[5.46 \times \frac{90-11.25}{90} + 4.51\left(\frac{90-33.75}{90}\right) + 3.19\left(\frac{90-56.25}{90}\right) + 1.12\left(\frac{90-78.75}{90}\right)\right] = 1.95^{K}$

= 425 #/in² ON GROSS AREA

(0 − 1.95 = 855# SHEAR CARRIED BY OTHER MECHANISMS.)

+ 1½" SLOPE OF LEG → 24.6 — 151 — 4 sub-d legs

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KARIOTIS & ASSOCIATES
STRUCTURAL ENGINEERS

SHT. C 10 OF
BY NELS
DATE 8-18-82
JOB NO. 82-104

SUBJECT: WATTS TOWERS
ITEM: WEST TOWER (C)

INVESTIGATE MECHANISM FOR RESISTING TEST LOAD

IF CENTER CORE IS LOADED @ ELEV +13.7 BY SPOKES

$M = P(13.7 - 7.2') = 6.5P^{\text{'k}}$

$13''\phi \quad S = \frac{\pi(13)^3}{32} = 216 \text{ in}^3$

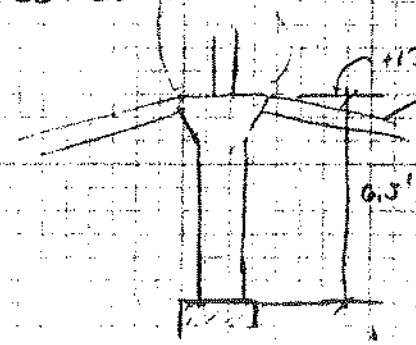
$wF_b = 600 \text{ PSI}, \quad M_{ALLOW} = \frac{216 \times 600}{12} = 10800^{\text{'\#}}$

$P = \frac{10800}{6.5} = \underline{1660}$

Deflection of center core under load of P = 1660#

$\Delta = \frac{P\ell^3}{3EI} = \frac{1.66(6.5)^3(1728)}{3 \times 2 \times 10^3 \times \frac{\pi(13)^4}{64}} = .094''$

CHECK EFFECT OF SPOKES & CENTER CORE ABOVE EL +13.7 IN RESISTING MOMENT & THUS PROVIDING PARTIAL FIXITY OF CENTER CORE



CTR COL ABOVE $I/_{10^4} = 491 \quad I/L = \frac{491}{6.5} = 76$

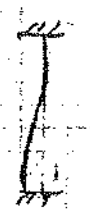
SPOKES $I/_{3''\text{SQ}} = 6.75 \times 8$ EFFECTIVE $= 54$

$\frac{I}{L} = \frac{54}{4.6} = 12 \quad .29$

CTR COL $I = \frac{\pi(13)^4}{64} = 1400$

$\frac{I}{L} = \frac{1400}{6.5} = 216 \quad \frac{.71}{1.00}$

MOM DIST



PEM = 5400

$M_T = 5400(1 - .71) = 1560^{\text{'k}}$ .19

$M_B = 5400 + 5400(.71)(1/2) = 7317$ .82

8883 1.00

$\frac{P}{A_{BASE}} = \frac{3920}{\frac{\pi(13)^2}{4}} = 29 \text{\#/in}^2$

$M_{b_{BASE}} = P(6.5)(.82) = 5.33P \quad F_{b_{TOT}} = 600 \text{ psi} + 29 = 629 \text{\#/in}^2 \quad M_{ALLOW} = \frac{216(629)}{12} = 11322$

$5.33P = 11322 \quad P = 2120^{\#}$

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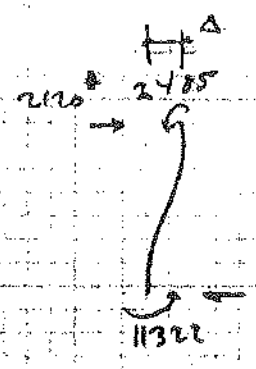
STRUCTURAL ENGINEERS

SHT. C 11 OF
BY DECS
DATE 8-20-82
JOB NO. 82-104

SUBJECT: Watts Towers
ITEM West Tower (C)



CENTER COLUMN DEFLECTION

$$\Delta_c = \frac{\frac{2120(6.5)^3(1728)}{3} - \frac{2485(6.5)^2(1728)}{2}}{2\times10^6 \times 1400} = .087'' \text{ @ EL } 13.7$$

I

COMPARE w/ Δ OF OUT COLUMN LEGS = .067 @ EL 8.3
SHT C8

THESE DEFLECTIONS APPEAR COMPATIBLE & IT SEEMS REASONABLE TO ASSUME LOADS ARE APPLIED TO EACH IN PROPORTION TO THEIR RELATIVE CAPACITIES

TOTAL SHEAR CAPACITY

1. O.T. RESISTED BY AXIAL LOAD IN LEGS — 1450#
2. OUTER LEGS IN FRAME ACTION — 3840#
3. CENTER CORE BENDING — 2120#

7410#

2 & 3 ARE BASED ON 600PSI TENSILE CAPACITY IN MORTAR

STRESS TO CARRY 10000# : $600\left(\frac{10000-1450}{3840+2120}\right) = 861$ PSI

TRY 900PSI

SHT 8 → 2 $V_{A\,LEGS} = 10{,}000\left(\frac{900+147}{1973}\right) =$ 5207

3 $V_{CTR\,CORE}\ (900+29)\frac{216}{12\times5.33} =$ 3137

8404
1450
9,850 ≃ 10,000

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SHT. C12 OF

BY NELS

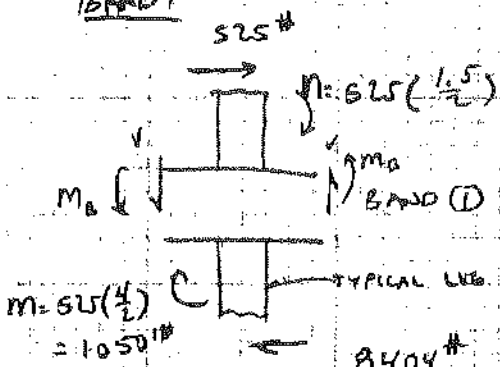
SUBJECT: WATTS TOWERS

DATE 3-20-82

ITEM WEST TOWER (C)

JOB NO. 82-104

BAND 1



$\frac{8404^{\#}}{16} = 525^{\#}$

$\begin{array}{r} 9^{L}10 \\ 8^{L}4 \\ \hline 1^{L}6 \end{array}$

$\begin{array}{r} 394 \\ 1050 \\ \hline 1444'^{\#} \end{array}$

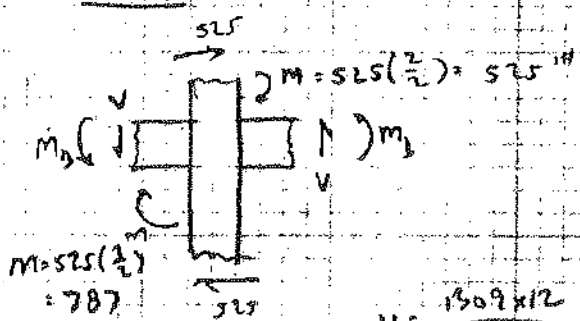
$V = \frac{1444'^{\#} \times 12}{29''} = 597^{\#}$ ← LEG SPACING

$M_B = 597(\frac{29}{2} - 3'') = 6866''^{\#}$

$f_b = \frac{6866}{7.5} = 915^{\#}/in^2$ – ABOUT SAME STATE OF STRESS AS LEG

1¼ x 6

BAND 5 – ASSUME SAME LOAD AS @ BASE



$\begin{array}{r} 525 \\ 784 \\ \hline 1309'^{\#} \end{array}$

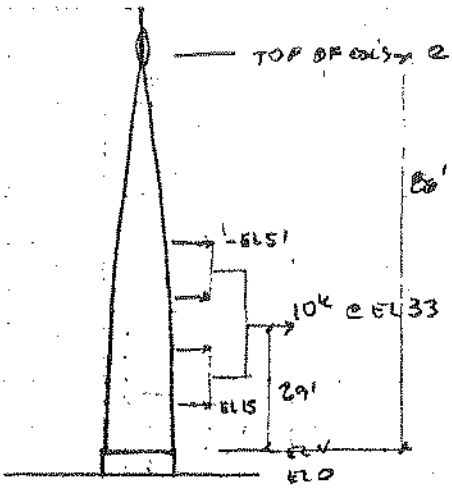
$V = \frac{1309 \times 12}{27.3} = 575^{k}$ ← LEG SPACING

$M_B = 575(\frac{27.3}{2} - 3'') = 6123'^{\#}$

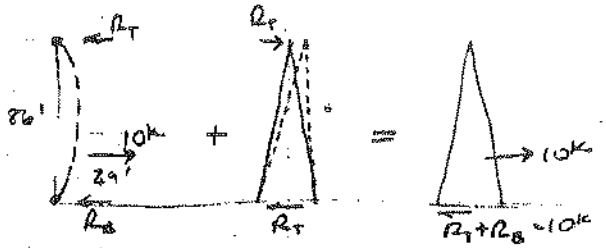
$f_b = \frac{6123}{\frac{1 \times 3.5^2}{6}} = 2979^{\#}/in^2$

1x3½" BAND

273



M_{OT} TOP OF PEDESTAL $= 10^K(29) = 290^{IK}$ $\quad R_T = \frac{290}{86'} = 3.37^K$

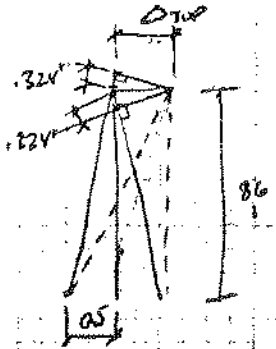


4 COLUMNS INTERSECT @ ELEVATION 90, OTHER COLS TERMINATE @ VARIOUS ELEVS 62'6 TO 88'6, BUT CALCULATE AVG COL STRESS BASED ON ALL COLUMNS TERMINATING @ INTERSECTION @ EL 90

∴, SEE SHT C9 — CALCULATE AXIAL ELONGATION ON BASIS OF UNIFORM VARIATION IN CROSSSECTIONAL AREA $14.3 in^2$ @ BASE, $3.1 in^2$ @ TOP

LEG 1 & 2 $\quad P = 5.46^K$

$$\Delta = \frac{PL}{AE} = \frac{5.46(86 \times 12)}{\frac{14.3+3.1}{2}(2 \times 10^3)} = 0.324" \qquad (.147)$$



$$\Delta_{TOP} = .324"\left(\frac{86}{6.5}\right) = 4.28" \qquad (1.94^M)$$

$$\Delta_{@\ EL\ 51'} = 4.28\left(\frac{51-4}{86}\right) = 2.34" \qquad (1.06")$$

$$\Delta_{@\ EL\ 15'} = 4.28\left(\frac{15-4}{86}\right) = .55" \qquad (.25")$$

ABUTMENTS NOT INCLUDED IF INCLUDED WOULD RESULT IN DEFLECTIONS OF ABOUT .45. THESE CALCULATED, THUS

DEFLECTIONS DUE TO ABOVE LEVELS COMBINED W/ FRAME DEFLECTIONS APPROXIMATELY ACCOUNT FOR LOAD TEST DEFLECTIONS

CLIENT EHRENKRANTZ

KARIOTIS & ASSOCIATES
STRUCTURAL ENGINEERS

SHT. C1 OF
BY V. GALS
DATE 9-17-82
JOB NO. 82-104

SUBJECT: WATTS TOWERS
ITEM WEST TOWER (2)

ESTIMATE CRACKED SECTION PROPERTIES - COLUMN 3

Uncracked Section: $I_{AVG\ UNCRACKED\ LEGS} = 16.3\ in^4$ (SHT C8)

$n = \frac{29 \times 10^6}{2 \times 10^6} = 14.5 \quad n-1 = 13.5$

Armature Numbers

$2" \times 2" \times 1/4"$ ∠ $A = .94\ in^2$ $\quad I_{\perp} = 0.35 \quad I_{\parallel} = 0.14 \quad I = 0.55 \quad (n-1)I_{max} = 7.4$

$(n-1)A = 12.69\ in^2$ $\quad (n-1)I_{min} = 1.9$

$AVG\ (n-1)I = 4.7$

$2\frac{1}{2} \times 2\frac{1}{2} \times 5/16$ TEE $\quad A = 1.62\ in^2 \quad I_{\perp} = .89 \quad I_{\parallel} = .44 \quad (n-1)I_{max} = 12.0$

$(n-1)A = 21.9\ in^2$ $\quad (n-1)I_{min} = 6.0$

$AVG\ (n-1)I_{min} = 9.0$

IF EACH KIND OF ARMATURE OCCURS IN 1/2 OF THE LEGS & EACH OCCURS IN POSITIONS ROTATED 360°, AVERAGE

$(n-1)I$ OF ARMATURE IS $\frac{4.7+9.0}{2} = 6.9\ in^4$ $\quad (n-1)A_{AVG\ ARMATURE} = \frac{12.3+21.9}{2} = 17.3"\ (0.55)$

$AVG\ I_{CONC} = \frac{16.3}{23.2\ in^4} \quad \frac{.70}{1.00}$ $\quad AVG\ A_{CONC} = 14.3"\ (0.45)$

$\Sigma I_{AVG} \quad \Sigma A_{AVG} \quad 31.6"\ (1.0)$

$S = \frac{23.2(2)}{4.3} = 10.8\ in^3$

AVG LOAD/COL = 625# } SHT C8

$M_{AVG} = 1200$

AXIAL LOAD BASED ON VERT D.L. $= \frac{32700}{16 \times 31.6} = 67\ \#/in^2$

If tensile strength of mortar is taken as $600\ \#/in^2$ total load capacity for this load path is

300 #/LEG

$M = (605+67)(10.8)in^3 = 7304\ in\#$ $\quad \Sigma V_{LEG} = \frac{7304(10.8\ in^3)}{12}\left(\frac{1}{4'}\right) \times 16 = 7802\#$ BASED ON LINEAR STRESS VARIATION ACRO CROSS SECTION

UNCRACKED SECTION

$\Delta = \frac{7802\ (\frac{4}{2})^3(1728)}{3 \times 2 \times 10^6 \times 23.2} \times 2 = .060\ in$

600 PSI

600 PSI

$M_{ARMATURE\ ALONE} \quad S_{AVG} = \frac{6.9 \times 2}{(n-1)} = 0.82\ in^3 \quad M = 0.82(16\ ksi) = 13,100\ in\#$ ELASTIC

LATERAL LOAD CARRIED BY LEGS: $\frac{13100}{12}\left(\frac{1}{4}\right)(16) = 8733\#$

CLIENT Ehrenkrantz Group

KARIOTIS & ASSOCIATES
STRUCTURAL ENGINEERS

SHT C19 OF

BY Nels

SUBJECT: Watts Towers

ITEM West Tower (C)

DATE 12.22.82

JOB NO. 82-104

ESTIMATE WIND LOAD ON TOWER

see sht 21

	A	p	F	h
.125 × 1 =	0.12	25.7	3	99.25
.54 × 1.5	0.81		21	98.0
.50 × 4.5	2.25		58	95.0
.92 × 0.75	0.69		18	92.4
.58 × 1.75	1.02		26	91.1
2.0 × 0.375	0.75		19	90.2
.58 × 1.375	0.80		21	89.6
2.0 × .375	0.75		19	88.5
1.25 × 1.37	1.72		44	87.4
2.0 × 0.21	0.42		11	86.8
1.25 × 1.79	2.24		58	85.6
4.0 × 0.33	1.32		34	84.7
1.5 × 1.0	1.5		39	84.0
4.5 × 0.33	1.5		39	83.5
1.62 × 2.42	3.93		101	82.0
5.0 × 0.25	1.25		32	80.7
1.75 × 2.25	3.94		127	79.4
2.0 × .33	0.66		17	78.2
2.0 × 1.42	2.90		75	77.2
2.0 × .33	0.67		17	77.0
4.0 × .29	1.16		30	76.5
2.04 × (5 − 1.74)	6.65		198	73.9
2.0 × .33	0.67		17	75.8
2.5 × .29	0.73		19	75.0
2.0 × .25	0.50		13	74.0
2.5 × .33	0.82		21	73
4.5 × .25	1.12		29	73
3.0 × .33	1.0		26	71.5
3.0 × .42	1.26		32	70.0
3.5 × .42	1.47		38	68.5
2.62 × 4.17	10.93		281	69.1
3.75 × .42	1.57		40	67.0
5.0 × .33	1.65		42	65.5
2.92 × 2.25	6.57		169	65.3
5.5 × .33	1.82		47	64

$M_{OT} = Fh$

$\Sigma F = 1762^{\#}$

$\Sigma M = 122800^{1\#}$

CLIENT [illegible]

KARIOTIS & ASSOCIATES
STRUCTURAL ENGINEERS

SHT. C20 OF
BY NELS
DATE 12-22-82
JOB NO. 82-104

SUBJECT: WATTS TOWERS
ITEM WEST TOWER (C)

$M_{OT} = Fh$

	A	p	F	h
2.42 × 1.67	4.88	25.7	125# +	62.8
6.0 × .42	2.52		65 +	62
3.33 × 2.75	9.16		235 +	60
9.00 × .33	3.00	23.4	70 +	58.5
3.00 × 2.33	7.00		164 +	56.6
6.5 × .5	3.25		76 +	58.5
6.5 × .42	2.73		64 +	57.0
7.0 × .33	2.31		54 +	55.0
5.33 × 2.0	10.67		250 +	53.3
11.0 × .25	2.75		64 +	52.0
4.0 × 2.25	10.0		234 +	50.4
7.5 × 0.5	3.75		88 +	51.0
7.5 × .33	2.57		59 +	49.0
5.33 × (7 - .58)	34.20		800 +	45.5
(8.0 × .67) + (4.0 × .25)	6.36		149 +	46.0
8.5 × .33	2.80		66 +	44.5
(9.0 × 0.67) + (4.5 × .25)	7.12		167 +	42.0
5.67 × 3.75	21.25	18.7	397 +	39.9
6.67 × 2.42	16.14		302 +	36.3
14.5 × .25	3.63		68 +	35.5
9.5 × .33	3.13		59 +	35.0
5.33 × 1.67	8.91		167 +	33.8
10.0 × 0.5	5.0		94 +	33.0
6.0 × 4.08	24.48		458 +	30.2
10.5 × .42	4.41		83 +	29.5
11.0 × .42	4.62		86 +	28.0
6.0 × 3.00	18.0		337 +	25.75
12.0 × .5	6.0		112 +	26.5
5.0 × .25	1.25		23 +	26.5
17 × .25	4.25		79 +	25.0
12.0 × .33	4.00		75 +	24.0
6.5 × 1.17	7.61		142 +	23.1
11.7 × .375	4.39		82 +	22.5
5.6 × [2.625 - (46 × .37)]	10.05		188 +	20.8
11.7 × .458 × .375	5.36		100 +	21.5
17.0 × .375	6.38		119 +	20.0
13.0 × .25	3.25	16.4	53 +	19.5

$\Sigma F = 5753^{\#}$

$\Sigma M_{OT} = 228750^{\#'}$

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STRUCTURAL ENGINEERS

SHT. C21 OF

BY Jells

SUBJECT: Watts Towers

DATE 12-22-82

ITEM West Tower (C)

JOB NO. 82-104

$M_{OT} = Fh$

	A	p	F	h
7.25×(3.75−.37)	24.47	16.4	401	17.4
12.5×.375	4.69		77	17.5
12.7×.5	6.25		103	15.5
6.83×[15.5−(4.0+1.91)] (ΣBand width)	65.5'		1074	9.75
17.3×.33	5.71		94	12.8
13.2×.33	4.36		72	12.5
12.6×.42	5.29		87	10.8
13.0×.33	4.29		70	9.8
12.8×0.5	6.40		105	8.3

$\Sigma F = 2082^{\#}$

$\Sigma M_{OT} = 24,980'^{\#}$

BASIS FOR WIND FORCE

1982 UBC

WIND SPEED ZONE: 70 MPH
EXPOSURE B
} $q_s = 13$

(FORMULA 11-1) $p = C_e(1.8)(13)(1.0) = 23.4^{\#}/ft^2 C_e$

h	Ce	p
0-20	.7	16.4
20-40	.8	18.7
40-60	1.0	23.4
60-100	1.1	25.7

TOTAL WIND LOAD

from C19, C20, C21

$\Sigma F = 1762 + 5753 + 2082 = 9600^{\#}$

$\Sigma M_{OT} = 133,800 + 228,800 + 25,000 = 387600'^{\#}$ ($\bar{h} = \frac{387600}{9600} = 40.4'$

BASE OF PEDISTAL

4'

36.4'

$M_{OT} = 387,600 - 9600(4) = 349,200'^{\#}$

@ TOP OF PEDISTAL

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STRUCTURAL ENGINEERS

SHT. C22 OF
BY [illegible]
DATE 12-20-87
JOB NO. 82-104

SUBJECT: WATTS TOWERS
ITEM WEST TOWER (C)

ESTIMATE RESPONSE OF WEST TOWER TO PROBABLE EARTHQUAKE:

SAY EPA = 0.2 MAX RESPONSE A: .2 × 2.5 = 0.5

E_V = 6"/SEC MAX RESPONSE V: 6 × 2.5 = 15"/SEC

BY CHART OF SHEET C6,

RESPONSE ACCELERATION W/ PERIOD OF .62 SEC = 0.4g

RESPONSE FORCE: .4(37500) = 15000#

BUT ABOVE 10,000# OF RESPONSE FORCE, MICRO CRACKING WILL OCCUR TO INCREASE PERIOD & REDUCE RESPONSE.

ESTIMATE PERIOD = 0.8 SEC

RESPONSE FORCE = 0.3G = .3(37500) = 11,200#

M_{OT} = 11,200(34.8') = 390,000'#

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STRUCTURAL ENGINEERS

SHT C 23 OF

BY DEC

SUBJECT: WATTS TOWERS

DATE 12-29-92

ITEM WEST TOWER

JOB NO. 92-104

PROBABLE RESPONSE @ BASE: $V = 37620(.3) = 11,300^{\#}$ $M_{OT} = 11,300(34.5-4) = 347,000^{\#}$

PROBABLE RESPONSE @ ELEV 24' (ABOUT 1/4 HT OF TOWER)

$$V = (5860 + 3080 + 14910)(.3) = 7155^{\#}$$

$$M_{OT} = \left[5860(72.26-24) + 3080(54.85-24) + 14910(33.66-24)\right]0.3 = 156,500^{\#}$$

$= 45\%$ OF MeBASE

SIGNIFICANT
∴ REQUIRES
STRUCT CONTINUITY.

PROBABLE RESPONSE @ ELEV 35' (ABOUT 1/3 HT OF TOWER) AT TOP OF DIAG BRACING BAND

$$V = (5860 + 3085 + \tfrac{14910}{2})(.3) = 4920^{\#}$$

$$M_{OT} = \left[5860(72.26-35) + 3080(54.85-35) + 7460(6' \pm)\right]0.3 = 97300 = 28\%$$ OF MeBASE

51
35
16

SLOPE OF LEGS IN ABOUT $\frac{1}{12}$

IF MECHANISM FOR LOAD RESISTANCE IS
MAINLY TENSION & COMPRESSION IN COLUMNS,
DIAMETER OF LEG PATTERN @ ELEV 35 IS 9'-4":

FOLLOWING PATTERN OF SHT C9

LEG 1&2 / 9&12 : $P = \dfrac{97300(.24)}{2\pi \times 9.3} = \pm 2.5^{K}$ ABOUT 1/2 OF LOAD @ BASE ∴ WOULD JUSTIFY PRESTRESSING STRUCT CONTINUITY IN 1/2 OF COLUMNS ABOVE EL 35'

LEG 3&6, 8&11 $P =$ 2.0^{K}

4&5, 7&12 $P =$ 1.4^{K}

LEG 5&11, 6&13 $P =$ 0.5^{K}

HORIZ COMPONENT OF O.T. FORCE

$$\frac{\left[2.5\left(\frac{90-11.25}{90}\right) + 2.0\left(\frac{90-33.75}{90}\right) + 1.4\left(\frac{90-56.25}{90}\right) + 0.5\left(\frac{90-78.75}{90}\right)\right]9}{12.7} = 1.29^{K}$$

$4.92 - 1.29 = 3.63^{K}$ CARRIED BY OTHER MECHANISMS
SUCH AS FRAME ACTION

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STRUCTURAL ENGINEERS

SHT. 04 OF

BY JEKS

SUBJECT: WATTS TOWERS

DATE 12-22-82

ITEM CENTER TOWER (D)

JOB NO. 82-104

ESTIMATE WIND LOAD ON TOWER

	A	p	F	h	M_{OT} = Fh
.125 x 2.0	0.25	25.7	6 ✓	96'	
.5 x 1.0	0.5		13 ✓	94.5	
.75 x 3.5	2.63		68 ✓	92.2	
.83 x 1.0	0.83		21 ✓	90.0	
.67 x 2.25	1.51 o		o 39 ✓	88.2	
1.0 x .25	0.25		6 ✓	89.5	
1.0 x .33	0.33		8 ✓	87.0	
0.75 x 3.0	2.25		58 ✓	85.5	
1.5 x .21	0.31		8 ✓	86.0	
1.5 x .25	0.38 o		10 ✓	85.0	
1.5 x .25	0.38		10 ✓	84.0	
1.0 x 1.75	1.75		45 ✓	82.9	
1.7 x 0.33	0.56		14 ✓	82.0	
1.67 x 1.67	2.79		72 ✓	81.0	
0.8 x .33	0.590		15 ✓	80.0	
1.67 x 1.67	2.79		72 ✓	79.0	
2.67 x 1.17	3.12		80 ✓	77.1	
3.0 x .33	1.0		26 ✓	76.5	
2.33 x 0.67	1.56		40 ✓	76.3	
1.0 x 1.0	1.0 o		26 ✓	75.5	
2.0 x .33	0.67		17	75.5	
2.33 x 1.0	2.33		60 ✓	74.5	
3.0 x 0.33	1.0		26 ✓	74.0	
2.33 1.17	2.73		70 ✓	73.1	
3.0 x .33	1.0 o		26 ✓	72.5	
2.33 x 1.17	2.73		70 ✓	71.6	
3.5 x .33	1.16		30 ✓	71.0	
2.33 x 1.67	3.89		100 ✓	69.7	
3.5 x 0.33	1.16		30 ✓	69.0	
2.33 x 1.33	3.100		80 ✓	68.0	
1.33 x 0.75	1.00		26 ✓	67.0	
(3.5-1.33)(0.42)	0.91		23 ✓	67.0	
2.67(5.08-.42x2-.33x2)	9.56		246	64.0	
4.0(.42)	1.68		43 ✓	65.5	$\Sigma F = 1516$
4.0(.33)	1.320	162	34 ✓	64.5	$\Sigma M_{OT} = 113805$

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KARIOTIS & ASSOCIATES
STRUCTURAL ENGINEERS

SHT. 05 OF

BY NELS

SUBJECT: WATTS TOWERS

DATE 12-22-82

ITEM CENTER TOWER (D)

JOB NO. 82-104

	A	ℓ	F	h	Fh = M_{OT}
4.5 x .33	1.49	25.7	38	63.5	
4.5 x .42	1.89		49	62.5	
1.0 x .58	0.58		15	61.8	
4.5 x .33	1.49		38	61.5	
4.0 x 1.67	6.68		172	60.3	
4.5 x .42	1.89	23.4	44	59.5	
3.67 x [7.08 − (61 x .33)]	22.3		521	55.5	
4.5 x .33	1.49		35	57.0	
5.0 x .67	3.35		78	55.5	
5.5 x .42	2.31		54	52	
4.6 x 2.08	9.57		224	50.5	
5.5 x .58	3.19		75	49.5	
4.6 x 4.42	20.33		475	46.7	
6.0 x .67	4.02		94	44.5	
5.0 x (2.33 − .33)	10.0		234	42.7	
5.5 x .33	1.82		43	43.5	
5.5 x .37	1.82		43	41.5	
4.58 x (4.17 − .33)	17.59	18.7	330	39.1	
6.0 x .33)	2.0		37	39.0	
6.0 x .33	2.0		37	39.0	
5.83 x [5.67 − (42.5)]	27.69		518	33.8	
6.5 x .42	2.73		51	35.5	
8.0 x .5	4.0		75	33.0	
7.0 x .33	2.31		43	31.0	
5.17 x [5.67 − .58]	26.3		492	27.8	
9.0 x .58	5.22		98	27.0	
7.0 x .42	2.94		55	25.0	
2 BAYS WIDTHS 5.58 x (4.58 − 1.08)	19.53		365	22.3	
10.0 x .5	5.00		94	23.5	
10.0 x .58	5.830		109	21.0	
10.0 x .33	3.33	16.4	55	18.0	
11.0 x .42	4.58		75	10.0	
10 x .33	3.33		55	9.0	
10 x .42	4.17		68	7.0	
2 BAYS WIDTHS 5.58 x (20 − 1.83 − 2.0)	101.59		1662	6.5	
PEDESTAL H1	84.6				

$\Sigma F = 6434^{\#}$

$\Sigma M_{OT} = 203,300^{\#}$

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STRUCTURAL ENGINEERS

SHT. D6 OF

BY NPEL

SUBJECT: WATTS TOWERS

DATE 12-23-82

ITEM CENTER TOWER (D)

JOB NO. 82-104

TOTAL WINDLOAD

$\Sigma F = 1516 + 6434 = 7950\ \#$ WIND V

$\Sigma M_{OT} = 113805 + 203,300 = 317,100^{1\#}$

$\bar{h} = 39.9'$

M_{OT} @ TOP OF PEDESTAL $= 317,100 - 7950(3) = 293,200^{1\#}$ WIND O.T

SEISMIC

ESTIMATE LATERAL LOAD @ 0.3g:

$0.3(29,200) = 8760$ SEISMIC V

$M_{OT} = 8760(31.3') = 274,400$ SEISMIC O.T.

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STRUCTURAL ENGINEERS

SHT. E-1 OF

BY NELS

SUBJECT: WATTS TOWER

DATE 12-27-82

ITEM EAST TOWER

JOB NO. 82-104

WIND LOAD ON ERET TOWER

		A	p	F	h
	.25 (3.08)	0.77	23.4	18.0	53.5
	.33 (1.0)	0.33		7.7	51.Y
	1.5 (.21)	0.32		7.5	50.0
	.63(2.0-.21)	1.49		35.9	49.9
	.92 (.92)	0.85		19.9	48.5
	1.0 (1.58)	1.58		37.0	47.1
	2.0 (.25)	0.50		11.7	47.1
	1.17 (.29)	0.34		8.0	46.2
-5'	5.0 (.25)	1.25		29.2	45.3
	0.83(1.8)	1.49		34.9	45.0
	0.75 (4.16)	3.12		73.0	43.7
	1.42(.25)	0.36		8.4	42.5
	5.0(.71)	1.05		24.6	41.9
	1.5 (.25)	0.38		8.9	40.5
	1.25 (2.0)	2.50		58.5	40.1
-93'	1.8 (10)	18.0	18.7	336.6	35.0
-30'	2.7 (6)	16.2	18.7	302.9	25.0
-24'	3.7 (4)	14.8	18.7	276.8	22.0
16'-20' COLS	4.08' x 15.5'	62.8	16.4	1029.9	12.2
5-20 BANDS		17.7	16.4	290.3	12.2

COLUMNS

CENTER COL $\frac{14+44}{2}$ = 29"

OTHER COLS 4@5" 20

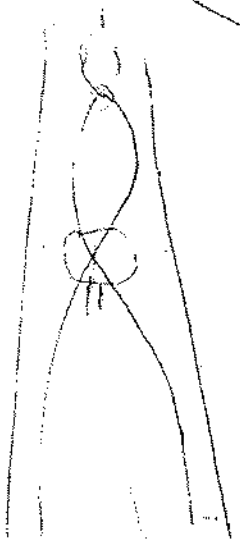
49"

BANDS = 4.08'

INNER $(6-4.08)\left(\frac{.25}{2}\times 16\right)$ = 2 SQ FT

OUTER $\left(\frac{10+6}{2}-4.08\right)\frac{.5}{1.5}\times 12$ = 15.7 SQ FT

17.7



$\Sigma F = 2620^{\#}$

$\Sigma M_{OT} = 59,467^{\#}$ $\quad \bar{h} = \frac{59467}{2619} = 22.7'$

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KARIOTIS & ASSOCIATES
STRUCTURAL ENGINEERS

SHT. P-1 OF
BY NELS
DATE 12-22-82
JOB NO. 82-104

SUBJECT: WATTS TOWERS
ITEM PERGOLA

WIND & OT. AT TOP OF ARCH

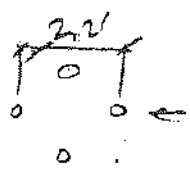
	A	p	F	h	h TO DISC @ EL 12.5
.25(1)	.25	23.4	5.85	40.5 - 12.5 =	28.0
.6 (10)	6.0	18.7	112.2	35.0 - 12.5	22.5
0.75+.33 (11) (COLS BACK)	10.83		202.5	24.5 - 12.5	12.0
(.67-.25)(1)	0.42		7.8	21 - 12.5	8.5
(1.17-.25)(1)	0.92		17.2	20 - 12.5	7.5
(1.17-.25)(1)	0.92	16.4	15.1	19 - 12.5	6.5
(2.0+.33)(6.5)	15.1	16.4	247.6	15.75 - 12.5 =	3.25'

$\Sigma F = 608^{\#}$ $\qquad \Sigma M_{OT} = 6217'^{\#}$

$$h = \frac{6217}{608} = 10.2'$$

608# SHEAR IN 6"Ø CENTER CORE - TRANSFERRED TO DOME @ 3'-6" DIA DISC @ EL 12.5'

$$\frac{608}{.785(6)^2} = 21\ \#/in^2$$



6217'# IN OUTER COLUMNS
1 IN COMPRESSION
1 IN TENSION

$$C = T = \frac{6217}{2.2'} = 2825^{\#} \qquad f = \frac{2825}{3''SQ} = 314\ \#/in^2 \text{ IN GROSS SECTION}$$

$$A_{STL\ YIELD} = \frac{2825}{33{,}000} < .1\ in^2 \text{ PROBABLY OK.}$$

MOMENT IS TRANSFERRED TO DOME MEMBERS BY 3'-6" DIA DISC @ ELEV 12.5, - PART BY C & T IN DOME MEMBERS (SEE NEXT SHT) & PART IN M & T

IF EACH MEMBER RESISTS AN EQUAL PORTION OF THE TOTAL M,

MOMENT
TORQUE MOMENT

$$\& \Sigma \Delta T + \Delta M = .5M, \quad \Delta T + \Delta M = \frac{6217(5)}{19} = 165\ '^{\#} = 2000''^{\#}$$

EACH MEMBER (SHEAR DISCOUNTED & ↗ BUT EFFECTIVE)

ASSUME TOTAL SAME FOR EACH MEMBER BUT PROPORTION OF ΔT OR ΔM VARIES W/ ORIENTATION

$$f_{b\ \text{BOTTOM}\ 3\frac{1}{4}''SQ} = \frac{(2000)(4.8 \times 3.25)}{(3.25)^4} = 280\ \#/\text{HIGH}$$

$$f_{b\ 4''SQ} = \frac{2000}{5.7} = 350\ \#/in^2 < 600\ \#/in$$

$$S_{4''SQ} = \frac{2.25^3}{6} = 5.7\ in^3$$

ON BASIS OF ΣΔT+ΔM=.5M BUT PROPORTION UNCERTAIN & ∴ THIS STRESS MAY BE HIGHER. ∴ CRITICAL.

CLIENT EHRENKRANTZ GROUP | KARIOTIS & ASSOCIATES STRUCTURAL ENGINEERS | SHT. P2 OF

BY NECJ

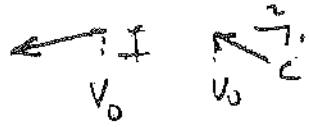
SUBJECT: WATTS TOWERS | DATE 12-22-82

ITEM PERGOLA | JOB NO. 82-104

$6217^{1-H} = M_{OT}$

IF VERTICAL COMPONENTS OF PERGOLAT ARCH MEMBERS RESIST 50% OF M_{OT}

$V_D = V_U = \frac{4000}{3.0} = 1330^{\#}$

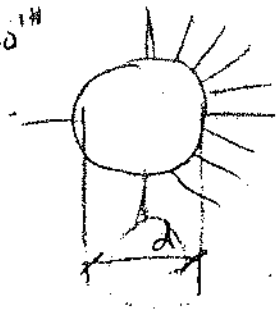


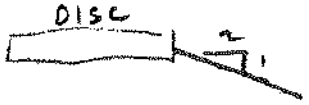
C AVG EFFECTIVE (d)

IF, $\Sigma(\Delta T \to \Delta M) = 6217(.5)$, USED ON SHT P1

THEN $\Sigma M_{C \text{ OF } T} = 6217(.5) = 3100^{1-H}$

BUT USE 4000^{1-H}





IF 4 LEGS RESIST $1330^{\#}$, $330^{\#}$ UPLIFT COMPONENT

$C = T = 330\frac{\sqrt{2^2+1^2}}{1}$

$= 740^{\#}$

O.K.

III. EVALUATION

III. EVALUATION

A. GRAPHIC RECORDING METHODS

In evaluating the need and feasibility of photogrammetric recording of Watts Towers, one must first understand the purpose of such an effort. Traditionally, graphic recording has served two functions for historic structures:

- Providing detailed documentation with a view toward facilitating its replication in the event of damage to the structure; and

- establishing a visual baseline to judge the effects of restoration, repairs or weathering to the structure.

Both goals can clearly be applied to Watts Towers. The structures are of recognized national architectural significance, making some form of recording valuable insurance against potential destruction. The ongoing program of repairs and restoration, as well as continuing deterioration, may also potentially require replacement of significant portions of original fabric, thus making baseline documentation desirable.

Despite the clear value of photogrammetric recording for the Towers, their complex configuration tests the limits of that technique. Therefore, it seems appropriate to discuss the potential advantages, costs and limitations of photogrammetry as well as a range of other available recording techniques. These are presented in chart format in Figure 80.

As this matrix indicates, no single method can reasonably provide sufficient and accurate documentation for the unique character of Watts Towers. Therefore, we recommend that a combination of techniques be utilized, as follows:

1. Measured site plan, prepared using standard survey techniques. An accurate plan is essential in order to record the location of towers, walls, and other decorative elements, as well as to provide a key for additional photos and/or drawings of sections, elevations or details of these elements.

2. Photogrammetric cross-sections and/or elevations, required to establish the location of horizontal and vertical elements within the structures and to provide a corresponding key for detail photos and work records of individual elements.

3. Rectified photographs of the perimeter walls and typical decorative details. The perimeter walls, as flat planes and areas most vulnerable to damage by vandalism, can be accurately and comprehensively recorded in this manner. By selecting typical decorative details throughout the sites, more precise information than obtainable through large-scale drawings can be provided.

4. Improved system of progress photographs for repair work. The present system offers excellent potential for detailed recording of critical areas. Methods should be upgraded to improve accuracy and permanence, as detailed in Section III.B.

5. Development of a generalized computer graphic model should be considered to provide yet another dimension to recording and analysis activities at the Towers. A rough model may be developed relatively easily from data generated by the measured site plan, sections and elevations. It can then be refined and updated with data from detail photographs of specific areas as that becomes available. Such a model would enable the towers to be studied from all possible angles and would be a valuable supplement to structural calculations.

Because of the complex nature of the Towers and the recommended recording methods, no photogrammetry firm has been willing to prepare final cost estimates without making a trip to the site. (See appended proposals.) Estimates prepared by Perry Borchers of Ohio State University in 1980 and 1981 provide several figures for photogrammetry. The first ($45,000) covered costs of a 3-person HABS team on site for 2 to 3 weeks, producing 2 to 3 elevation drawings. Later, a figure of $16,900 was given. Ken Anderson of HABS cited $50,000 as a "fair estimate" for photogrammetry. We recommend that the State issue a formal request for proposals covering development of a site plan, cross-section and rectified photographs.

The request for proposal should include the following specifications, which represent minimum requirements for documentation:

1. Measured Site Plan: Prepare one site plan at 1/8" scale. Cut shall be taken at a height sufficient to show position of columns in Gazebo, East Tower, Center Tower, etc. Drawing shall be of sufficient detail to show location of planters, benches, steps, and selected floor treatment. Plan shall be drawn in ink or mylar and comply with graphic documentation standards of the Historic American Buildings Survey.

2. Rectified Photographs, Walls and Ornament: Wall documentation shall include overall views of all sides of northeast and south walls and detailed photographs of each decorated bay on the walls (approximately 675 views). Detail photographs shall be keyed to large-scale elevation photos.

   Photograph representative ornament on the House, Gazebo, West Tower, Center Tower, East Tower and Ship. Details shall be selected to illustrate the complete range of decorative materials and configurations. All views should be keyed to plans and section drawings and identified with the nonmenclature system in use by OSA staff. Photographs shall be scale-rectified in 4x5, 5x7 or 8x10 format. Exposure, composition, developing and printing shall conform to standards of the Historic American Buildings Survey. Photog aphs of tower detail should be taken while scaffolding is in place.

3. Elevations, Sections and Upper Level Plans:

a. Prepare one overall site elevation at 1/8 scale. View shall be taken from the south side of the side and show only outer members of circular structures in order to preserve clarity of presentation.

b. Prepare 1/8 scale cross-sections of the following structures: Gazebo, Small Tower #1, Small Tower #2, Pinnacles, West Tower, Center Tower, East Tower, Ship (west-east).

c. Prepare 1/8 scale horizontal sections or upper level plans of the West Tower Center Tower and East Tower. Location of plans shall be selected to show changes in configuration from the ground plan (approximately 7 plans) and connections to adjacent structures.

All drawings shall be prepared in ink on mylar from photogrammetric stereopairs supplemented hand measurement as required. Sketches prepared by the Los Angeles Department of Buildings and Safety in 1959 shall be provided for reference but all dimensions must be field-verified. Work shall conform to standards set by HABS. Drawings shall incorporate the identification system in use by OSA staff.

Estimated costs for the work outlined above are as follows:

1. Site Plan:		
on site, 4 days @ $500/day	$2000.	
drafting, 1 sheet @ $	$3000.	$5,000.
2. Rectified Photography:		
on site, 3 days @ $500/day	$1500.	
100 prints @ $25/print	$2500	$4000.
3. Elevations, Sections, Upper Level Plans:		
on site, 4 days @ $1100.	$4400.	
Stereoplotting & drafting 4 sheets @ $500	$2000.	$6400.
		$15,400.

Plus travel expenses.

GRAPHIC RECORDING OPTIONS

TECHNIQUE	PRODUCT/ADVANTAGES	COST	LIMITATIONS
1. Present system of progress photos.			Provides no overall record of the structures. Accuracy and completeness dependent on skill and patience of site staff.
2. Scaled-rectified photography	Detailed photographs scaled for actual dimensions and corrected for perspective; multiple images may be joined in a "mosaic" for large-scale structures. Can be photographed in color but since color film is not archivally stable, must use 3-color separation negatives to show ornament patterns. Could be prepared by aerial survey to rough scale.	Approximately $25/ black & white print plus on-site work costs. (major cost element)/ accurate fee not possible without site visit.	Rectification relies on the existence of flat planes parallel to the camera plane, a situation which does not exist at the Towers. Site conditions and structure may make access for accurate close-up photography difficult.
3. Stero photography	Initial product a series of scaled, overlapping photographs ("stereo pairs") which provide a three-dimensional image. Final product a series of scaled plans, elevations and/or sections. Similar detail and accuracy as 2.	$12/stereopair plus on-site and stereo plotting costs. (major cost element)/Accurate fee not possible without site visit.	Irregular and non-planar structure of Towers makes selection of traditional orthographic projections problemmatic. See also 2 above.
4. Video Recording	Series of taped "tours" with voice-over describing location (keyed to plans, elevations or other location system), conditions or other relevant details. Complete three dimensional image. Can be accomplished from present scaffold. Use 3/4" professional format.		Image and detail not clear. Non-reproduceable
5. Computer-generated graphics	Paired images can be prepared as in stereo-photogrammetry, fed into a plotter and digitalized to provide 3-dimensional mapping of an object. Alternatively, a generalized 3-dimensional model of the towers could be prepared based on rough dimensions and plan, section and elevation data. Could be supplemented with detail information as that becomes available. Could be used for structural calculations.		End result requires photography of every square inch of sculpture surface. Same rectification limitations as photogrammetry - but product usable in generalized form before end of plotting.
6. Hand measured drawings	Initial field measurements and sketches Transcribed into measured line drawings.		Amount of detail limited by skill and patience of draftsman. Like other rectified techniques, is of limited value for non-planar subjects. Requires significantly greater field and drafting time than photogrammetry.
7. Scale model	Three dimensional replica showing each member as it relates to others in space and to nomenclature system.		Cannot reproduce detail at small scale. Provides no record of ornament or existing conditions.

Fig. 74

The Ehrenkrantz Group

Dennett, Muessig & Associates, Ltd.
631 South Van Buren, Iowa City, Iowa 52240 319-354-5519

27 January 1982

Ms. Sandra L. Suominen
THE EHRENKRANTZ GROUP, P.C.
Architects and Planners
140 Chestnut Street
San Fransisco, California 94111

Dear Ms. Suominen:

My apology for not replying to your December letters sooner. Our response to your inquiry has fallen victim of the holidays, the periodic snowstorms that have shut down activity throughout the mid-west during the past month, a field effort, and the complexity of your project itself. After studying the photographs of the Watts Towers that you sent, we have come to appreciate the enormity of developing a Preservation Plan for the site. Certainly the complexity of the towers makes coping with structural deterioration very difficult, and their overwhelming array of shapes and sizes makes any form of two-dimensional recording seem but a feeble representation of reality. Nevertheless, the more we have looked at the problems posed by the towers, the more difficult it has been to imagine effective preservation of them without using photographic documentation of the sorts our firm can provide.

On the basis of the information that we now have (both the images you provided and others we have come up with) it is very difficult to know what sort of recording strategy would be the most useful for both short-term restoration monitoring and long-term archival records of the structures. And without settling npon a photographic approach to the project (or a set of alternative approaches), it is virtually impossible to come up with realistic cost estimates. The complex nature of the Watts Towers site suggests that in order to assess the possible recording approaches intelligently, a visit to the site and consultation with your firm during the project planning stages will be necessary. A field inspection of the site would allow us to tailor our products to best suit your needs. It is an ironic reality of our photogrammetric work that, in order to plan projects effectively, we are so dependent upon photographs and measurements of the sites we propose to document. Site visits during the initial stages of a project prove generally to have been time well spent. But of all the projects I have been involved with, never have I seen one where a visit to the site and consultation with the client seemed so important as with the Watts Towers.

Having said that, at this point, I am not certain just what we should propose regarding recording the towers, I should go on to say that we have done a good deal of general thinking about ways in which photogrammetry might be nseful.

Several possible approaches to both the photographic recording and the graphic presentation of the towers have occurred to us, and a discussion of our preliminary ideas might suggest ways in which we might assist your preservation program for the site.

Our first thought is usually Stereophotogrammetric recording, and this is the approach you raised in your letter of 10 December. As a technique it offers some promise, but also raises theoretical questions that must be answered. The fundamental problem with photogrammetric recording is that when one goes beyond the point of seeing photogrammetry as the solution to a problem, decisions have to be made about the final product (or products) that influence the way in which the field work is done. Stereophotogrammetry could be effectively used to document the Watts Towers complex, and, however the photography was done, would preserve some three-dimensional data from the site. It would, therefore, serve to provide an archival record of the towers. It is when one goes beyond the question of preserving three-dimensional data to producing drawings from the stereopairs that the towers seem more of a problem. It is hard to see how one would choose to represent the towers, or sections of them, with the orthographic projections of traditional architect's drawings. And, given the construction materials, drawing them at any large scale seems contrary to the spirit of the structures themselves. I feel that it would be more in keeping with the nature of the site to develop a materials catalog for each area, than it would be to draw, with precise accuracy, the positions of shells, bottoms of bottles, and broken bits of tile. One graphic product of photogrammetric recording that might prove useful to a restoration effort, however, is drawing vertical and horizontal sections of individual towers. These would indicate whether any of the towers lean; and, if so, where. Vertical sections could be produced for each tower, probably drawn along more than a one plane. Each tower could also be drawn as a series of horizontal sections, and these could be plan sections drawn to show the positions of the main structural members in the areas between section lines.

Scaled-Rectified Photography would offer yet another approach to the problem of recording the Watts Towers. From the photographs we have of the structures it looks as though this might be an effective way to record at least the major elements of the site. The exteriors of the ground-level mosaic fences that line the two long sides of the tower complex's triangle are natural candidates for Scaled-Rectified Photography. We have not been able to tell from the photographs we have whether the inside of these fences is so elaborte as the outer surface, or whether they would be accessible for photography. Scaled-Rectified Photography could also be done, from the air, of the towers themselves, probably along the same planes as those chosen for the ground-level mosaic fences. This would be an effort to provide complete visual coverage of the monument at a consistent scale. Unlike the more common use for scaled photography, single-plane building facades, we would be working only to a rough sort of scale with the towers themselves because there would be no obvious plane to which we should scale accurately. However, we would keep the towers to a consistent relative size, while at the same time providing complete, high-quality visual coverage of the towers along the planes chosen. While we generally do large-format scaled photography in black and white, it could well be that color would be the best choice in this case.

Two other possible services that we might provide for a restoration effort on the Watts Towers have occurred to us. One would involve producing a

photographic inventory of the tower complex. The real question for such an approach would be one of deciding what constitutes sufficient coverage of the site. Certainly producing a visual inventory could prove to be an extremely complex effort, one that might involve photographing both the interiors and the exteriors of the towers using an involved cataloging system to keep track of the positions of each photograph. Yet another need you might have would be an accurate plan map of the site at a scale large enough to locate all the major features of the complex. The plan you sent us is done at too small a scale and is too general to to be really useful. It does not give enough positional information to enable us to design an effective photographic approach for the site. If a complete and accurate plan does not exist, we could provide one.

Since I have not provided you with a straight-forward proposal and budget, I thought a discussion of our fees would be in order. In general we calculate costs on the basis of a day rate plus expenses, and with large projects such as this one we usually work from "fixed-price" budgets. We normally do stereophotogrammetry with a crew of three from our office at a day rate of $1100. Current film costs are $12/stereopair (with each pair double-shot in black and white on glass plates); we charge $65/hour for stereoplotting and $20/hour for drafting and related graphic services. Our fees for Scaled-Rectified Photography are $500/day for a crew of two and $700/day for a crew of three; the complexity of the project determines which is necessary. As with stereophotogrammetry, film, per diem, and travel are the usual expenses. We normally provide scaled photographic prints in black and white at a cost of $25/print; color would probably be a little bit higher. As I have said above, I feel that the Watts Towers project would be extremely difficult to handle without a visit to the site and consultation with you in the early planning stages of the project. Our consulting fee for such initial project planning, with one of the principals to visit Los Angeles, would be $300/day plus travel. A day or two should, I think, be sufficient to deal with the questions of your needs and the photographic approaches that can best meet them.

I hope that I have been able to give you at least some idea of the ways we might prove to be helpful with the restoration of the Watts Towers. Often what we actually do in the field is not what we first proposed for a project; and, with a project so complex as Rodia's towers, this may very well be the case here. We are certainly very interested in the Watts Towers, and hope to have an opportunity to work with you on them.

Sincerely,

Robert A Ryan III

Robert A. Ryan
Vice President

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Whittaker

1 March 1982

RECEIVED
MAR 0 5 1982

Ms. Sandra L. Suominen
The Ehrenkrantz Group, P.C.
Architects and Planners
140 Chestnut Street
San Francisco, California 94111

Subject: Watts Towers Project

Dear Ms. Suominen:

In response to your query regarding photogrammetric recording and documentation support for your project to develop a preservation plan for the Watts Towers, we believe there are three levels of support which you should consider. These three levels may be characterized as follows:

OPTION I: Provision of documentary and archival photography which will satisfy the requiremtns of HABS. This option involves the use of view, graphic, and standard SLR cameras, with dimensional references and supplementary measurements to produce standard HABS-spec compliant prints, limited dimensioned line drawings, overall arrangement or site photos, and stable-base archival quality negatives of all imagery. A report is provided which provides technical data on all photography. Note that no stereophotogrammetric techniques are used in this simple option.

OPTION II: This option includes all work as per Option I, but provides a limited stereophotogrammetric result in addition. The stereo would consist of up to 10 separate views (stereo pairs). These views would be overall views of the site, and specific coverage of the three major towers. Stereo pairs would be reduced and plotted to give three ink-on-mylar single-line drawings with "as-built" overall dimensions. It should be noted that this is probably the only way to achieve such dimensioned as-built detail, other than by classical field survey techniques with transit, tape measure and scaffolding.

OPTION III: In addition to all work as discussed under the previous two options, complete stereophotogrammetric recording, development of digitized computer geometric data base, and preparation of computer-generated as-built drawings, for all elements of the complex. Details of members such as the "arches" which tie the towers above head-height can be generated.

As to budgetary cost figures for these options, we would expect Option I to be accomplished for about $25K. Option II would run $65K-$75K, dependent on field conditions for stereo sight distance, access on private property, and interference by trees, the boundary wall, or other elements which could require a larger-than-anticipated number of stereo set-ups.

With respect to Option III, the complete analysis and recording of the site, we simply cannot give you a cost estimate without a detailed site recon and evaluation. The best example of the type of detail achievable with this full-scale approach is probably the aircraft structure and exterior depicted in the attachments to this letter. You must bear in mind, however, that the problem of developing the computer model of an aircraft is made (relatively) simpler than the Watts Towers by facts such as regularity/symmetry of design, access to drawings, and several other factors which don't apply in this case of the Towers. To develop realistic cost estimates for this type of effort would require a field recon to the site and on-site discussions with a representative of your firm to define the extent of as-built drawings you would require. Such a recon and coordination visit would probably cost about $1,500.

I would suggest you consider Option I as an initial item of work. The actual contract terms would be Time and Materials. Hourly rate quotes can be supplied, with detailed project cost estimate if you are interested. Since I would assume the HABS-type archival documentation will be necessary whether you proceed with photogrammetric exploitation, this would not represent any exceptional cost. During the time our project team is on-site doing the photography, they can carry out the necessary recon, evaluations, and discussions with your people. Once that much is accomplished, we can then prepare an accurate statement of stereo work requirements, as-built drawing package, and cost estimate. The field evaluation is necessary, since the major cost of the effort will be in the collection and reduction of the raw field data. Once this input is transformed to computer model, the drawing itself requires relatively little cost.

This includes, by the way, not only overall as-builts, but details, auxiliary views and automatic sections as well.

I hope this input is helpful in your preparation of a proposal to the state. We would be delighted to work with you on this most interesting project.

Yours truly,

James A. Keller
Vice President, Marketing

JAK:dl
Enclosures

B. CURRENT REPAIR TECHNIQUES AND MATERIALS

1. Description of Existing Conditions

The following description of current repair techniques reflects visits to the site made by team members and discussions with Ward Treadwell and John Zillig of the Office of the State Architect. The same operations outlined in Treadwell's "Basic Repair Sequence" (see Historical Appendix 7) are currently being followed, with some modifications:

(Step 1) "Five minute epoxy" manufactured by Jolley Plastics is used to glue together broken ornament.

(Step 3) Rust inhibitor in use is ZRC cold galvanizing compound. The following types of stainless steel elements are in use:

--stainless steel welded wire cloth
--1/8" x 3/4" flat
--3/16" x 1" flat
--1/4" x 1/4" square and round
--3/8" x 3/8" square and round
--1/8" x 1 1/4" x 1 1/4" angles

New stainless steel members are attached to the original material with stainless steel bolts, then wrapped in the welded wire mesh.

(Step 7) Concrete cure no longer in use. Scratch coat and finish mortar and wet towel cured. No caulking of small fissures.

(Additional Step) Original fabric is saved and reassembled with "five minute epoxy." Excess original mortar is removed with a tile saw, saw kerf is left on back of fabric skins. Skins are dipped in water and fixed in place using slurry mix to wet mortar.

Typical repair operations are illustrated in Figs. 6, 26-31.

The staff currently follows a system of recording repair work that, while admirably thorough and refined through months of trial and error, retains some problems. The system includes the following elements:

a. Numbering all tower structural elements. Columns, distinguished between outer, intermediate, inner and central core, are numbered clockwise from the northernmost member; bands, loops, etc. are identified accordingly. The actual elements have been tagged with their identification numbers. Several materials have been used--plastic imprinted tapes, paper encased in plastic, adhesive tape and wire twists--but all disintegrate after a few months' exposure to the weather. (Figs. 11, 19, 25)

b. Numbering all repairs for each tower consecutively and logging them in a notebook. A packet is prepared for each repair,

including a cover sheet describing location and operations included in the repair (type of steel added, use of epoxy, sketches of new reinforcement) and preprinted cards containing photographs taken before, during and after the repairs. The craftsmen keep the cards with them while at work, so that notes and photo numbers can be recorded as they are made.

Treadwell suggests that the "after" photos may be a pointless exercise, since the finished work is there to be seen; they could, however, be valuable for future records and evaluation. Quality of the photographs is far below that desirable. An "Instamatic" camera and Kodachrome film are used. The former generally prevents close and accurate focusing; the latter is non-archival.

c. Repair booklets for each tower are filed in numerical order. Four copies are supposed to be sent to various agencies in Sacramento. Of the four copies one goes to the Department of Parks and Recreation, one to the City of Los Angeles, one to CSRTW, and one to the O.S.A. office.

Work is progressing from bottom to top; repairs are at about the 35-40 foot level on all towers as of late 1982. Attention is generally focused on primary structural elements, such as columns, bands and cross-bracing.

2. Evaluation

a. Structural

Structural Performance of the Towers. As detailed in Section II.C., the structural integrity of the towers under seismic or extreme wind loading depends upon the continuity of a space framework composed principally of the vertical members, the tower legs and central core. Capacity of the tower legs to resist the horizontal component of wind or seismic inertial shears is increased by the continuity of the vertical leg and horizontal elements such as bands, spokes and similar interconnections. The space framework, at the time of its construction and during the load test previously applied, had elastic axial tension capacity equal to the modulus of rupture limit of the mortar covering, supplemented by the central armature, with the strain in the central armature compatible with the strain in the mortar. Elastic compression capacity can be computed by a similar method. Elastic flexural capacity of the spaceframe assemblage is related to the modulus of rupture of the brittle mortar covering of the armatures. Disruption of the mortar covering by expansion of the armature, corrosion, or any action, has a significant impact on the structural integrity of the towers.

Probable Lateral Loads Imposed on the Towers. Extreme winds and earthquakes comprise the probable events that impose horizontal load effects on the towers. Extreme winds impose both static and dynamic loads on the towers. The combined maximum horizontal

component is probably due to about half near-static and half dynamic loading. If the towers had adequate elastic strength capacity, earthquakes that have the intensity of ground shaking anticipated for design of structures in the Los Angeles basin would cause horizontal inertial shear forces that would exceed wind horizontal shears. Earthquake design techniques are highly dependent on non-elastic (inelastic) performance of a structure. Inelastic performance can be characterized as retention of a load-carrying capacity after rupture of an elastic system. The original towers have an inelastic capacity. The original inelastic capacity cannot be quantified, but can only be given a probability due to the randomness of the original construction techniques.

If the randomness of the initial yield (exceedance of elastic strength capacity) is uniformly distributed throughout the space-frame, probabilities of survival of the structure can be calculated. The elements that influence the randomness of behavior are:

--Existing cracks in the mortar coating;
--Splices in the armature; and
--No continuity between vertical members and horizontal members.

Influence of Current Repair Techniques on Probable Performance under Lateral Loads. The present repair techniques, as previously described, replace a corroded armature and the fragmented mortar coating with a corrosion-resistant armature covered with salvaged mortar pieces laid as large-scale tiles. These techniques, if followed for all of future time, would remove a probable randomness of the joinery and replace the present tower structure with an assemblage of finite length members. This finite length would be less than the length between intersections of the space framework, and probability of physical separation due to tensile loads of all vertical members between bands would become high. The tensile loads discussed would be caused by lateral loads of wind or earthquake. Tensile separation in itself does not necessarily cause collapse under dynamic loads. Dynamic loads are cyclic in nature, and the tensile elongation is limited by the reversing nature of dynamic loads. However, if tensile elongation causes the members to lose compression capacity, partial collapse or severe damage to the framework can occur. In addition, the present installation of substantial size salvaged mortar pieces gives a moderate to high probability of the separation of these pieces during shaking of the towers. Threats to life are primarily posed by objects falling from above. The probable size of the pieces significantly increases the life-safety threat.

Conclusions. The present repair techniques do not restore the original continuity of the armature and increase the total number of splices in the armatures of the towers' framework.

The reinstallation of large-size salvaged fragments diminishes the probability of composite action of the armature and the mortar coating in determining the structural capacity of a repaired member.

The reinstallation of large-size or moderate-size fragments increases the probability of separation of pieces of the mortar coating large enough to pose life safety hazards during a wind storm or earthquake.

b. Metals and Metals Coatings. Use of stainless steel with the mild steel and iron does not appear to pose problems with galvanic potential, given the small proportion of stainless to ferrous metal.

Treatment of the exposed original metal by sandblasting and coating with ZRC appears to provide the best available protection against corrosion. For maximum effectiveness, however, the material must be applied to metal completely free of rust. During site visits, it was noted that "cleaned" metal frequently retained a light rust film, and protective coating was not immediately applied.

c. Repair Mortar. The repair mortar currently in use is essentially similar to Rodia's original mixes in composition, that is basically 1:3 cement to predominantly quartz/calcite sand. The present repair techniques nonetheless pose a number of problems, actual and potential, physical and aesthetic. These relate to conflicts between the functional requirements of mortar design. Necessary strength is bought at the expense of brittleness, and organic additives that can improve flexural strength tend to increase shrinkage and inhibit the effectiveness of water repellants. The design mix discussed in subsequent sections seeks the most judicious balance of attributes consistent with currently available techniques and materials. The following observations should be of some value.

mortar additives: The acryic polymer additive Acryl 60 is being used in two ways, at full concentration to prepare a neat cement slurry in order to improve adhesion and mechanical properties of subsequent mortar buildup, and as a 10% addition to mix water.

As a component of the slurry, Acryl 60 is convenient, being a one-component liquid. We recommend, however, that this slurry's use be confined to the rebonding of hardened original mortar pieces replaced in the repair of structurally non-critical members. The only other use of bonding agents we recommend is on the armature prior to the application of the first coat of mortar. In these cases Sikadur Hi-Mod 2 part epoxy bonding agent should be used. No bonding agent should be used between subsequent mortar buildup layers.

As an additive to mix water the consequences of using 10% Acryl 60 are less clear, Thoro System Products, say in their technical bulletin 67E that one part of Acryl 60 to 2 parts water should be used for mixing cement plastics to be built up in 1/4"-3/8" thicknesses. This produces a "plasticized" mix having good adhesion and workability and greatly improved tensile and flexural

strength (also improved compressive strength, but this is less significant). The hardened mortar is basically much less brittle than a traditional 1:3 style mortar. This might be considered an advantage for use at the towers, except that this quality is bought at the expense of greater shrinkage in curing and molecular modification of the mortar. Obviously the shrinkage can be a problem when patching members of the type found on the towers, typically inducing microcracking adjacent to original work. The alteration of molecular and pore structure of the mortar has a different consequence. It means that true water repellants cannot be used on the repair mortar because the acrylic, when used at the concentrations recommended inhibits the chemical reaction necessary between the alkyl-alkoxy-silane and the surface of the mortar. Non-penetrating waterproof coatings which rely on simple adhesion to the mortar would not be so affected, but as discussed later these are not recommended for use on the towers in any case.

In order to determine whether the weak 10% Acryl 60 solution presently used for mortar mix water would affect subsequent applications, tests were conducted which are described in Section IV A. The tests show that the effectiveness of the best performing water repellent is not affected by use of 10% Acryl 60 in the mix water to improve workability and adhesion.

repair finish: The 1979 Conservation and Maintenance Plan for Watts Towers specifies that:

"All repair mortar will be colored a uniform color to blend unobtrusively with the original mortar colors yet easily distinguishable from the artist's work. The mortar will be tooled to a smooth texture with a slight relief where it meets the original mortar to further distinguish the repair from the original work."

Given the extent of repairs required, not to mention work which may be anticipated in the future, this procedure poses greater harm to the interpretation of the work by overwhelming the original material with the repair, than would more careful attempts to match the original. The "uniform color" cannot "blend unobtrusively" when the repair mortar is gray and the surrounding original mortar is red. The present system of recessing the edges and brushing the surface slightly to provide a similar texture to that in Rodia's work seems adequate. By this means, a repair may be clearly distinguishable at close range but blend easily from afar.

d. Replacement of Ornament. In all cases where surface ecoration is clearly documented and original elements are at hand, they should be replaced.

Use of the proprietary "five minute epoxy" manufactured by Jolly Plastics for adhesion of original mortar fragments seems unwise. The material is known to yellow upon exposure and cannot provide any guarantee of long-lasting service or compatibility with the

original system. It's use should be discontinued.

Use of the Vulkem gun-grade adhesive for attaching loose ornament also appears questionable. Manufacturer's data suggests use of a primer for proper adhesion to tile.

Opticon UV has been used for glass-glass adhesive. This is an excellent material, but repair of the individual ornaments consumes valuable time. Instead, the back side of the parts may be covered with a sealant/adhesive and the parts of the ornament placed onto the original mortar surface. This will also accommodate further movement without damage to the decoration. The product recommended for this application is Dow Corning 795 silicone building sealant, which is also recommended for use as temporary caulking in cracks. (see Section III C.3 following)

e. Recording System. The current system of recording repairs is excellent. Minor improvements are suggested in Section III.C.

C. RECOMMENDATIONS FOR MODIFICATIONS TO CURRENT REPAIR TECHNIQUES

1. Structural

As stated in the previous section, the present system of repair does not restore the original continuity of the structure and increases the potential for failure within it. Therefore, where the initial excavation of a repair area indicates that the original armature has lost sufficient amounts of cross-section to require replacement, we recommend that the entire member be replaced. The original fabric should be sawed off in sections and replaced on the new, stainless-steel armature, using the materials and methodology outlined below. The repaired member should then be re-joined to the towers, using the same method of splicing or wrapping as employed by Rodia. Use of bolts is to be discontinued, as the hole required for the bolt removes so much cross-section as to impose excessive stress on the remaining member. (See Section II.C Structural Analysis of Towers.)

Replacement of large portions of the original fabric will not eliminate the life safety hazard due to separation of these fragments during a wind storm or earthquake. In order to preserve as much of the original fabric as possible, however, we recommend that this practice continue on non-critical structural members. In these cases an Acryl 60 slurry coat on the back of the fragment may be applied as a bonding agent prior to setting it in the fresh mortar of the repair. No other use of bonding agents should be allowed except prior to application of the first layer of mortar, Sikadur Hi-mod epoxy is to be applied to the armature whether new or original (see Figure 74 on the next page).

The logic of this approach is to enhance adhesion of new mortar to the armature and to protect the armature from corrosion. By not using an organic bonder between subsequent layers of mortar the eventual penetration of water repellent is not inhibited. In the case of Acryl 60 slurry used to bond larger fragments of original material to the outermost layer of fresh mortar the judgement is made that the thickness of such fragments is adequate to ensure good penetration of water-repellent before it encounters the film of Acryl 60 based material.

Where existing armature is retained, metal must be cleaned to "commercial blast" finish and primed within three hours. All holes or gaps in the metal must be filled with mortar in order to prevent further contact with water.

SIKASTIX 370

SIKADUR HI-MOD

High-modulus Epoxy Adhesive to Bond Fresh Concrete to Hardened Concrete

USE: Polysulfide-free, rigid epoxy adhesive. Use neat to bond fresh, plastic concrete to sound, hardened concrete. Use with Sikaset C to produce permanently bonded quick-setting highway patches. See page 61.

Use neat to anchor bolts if bolt hole is ⅛ in. or less larger than bolt dia.

DESCRIPTION: 2-component epoxy-resin system with easy-mix, 1:1 ratio between components.

Apply at temperatures as low as 40F.

Packaging: 10-gal, 4-gal, 2-gal pails; 1-qt units, 12/case.
Shelf life: 1 yr.

ADVANTAGES: Wafer-thin glue line bonds plastic concrete to hardened concrete with monolithic integrity.

SURFACE PREPARATION: *Concrete:* Surface must be clean and sound. It may be dry, damp, or wet, but free of standing water. Remove dust, laitance, grease, curing compounds, impregnations, waxes, foreign particles, and disintegrated materials by mechanical abrasion methods such as sandblasting. *Steel:* Sandblast to appropriate finish.

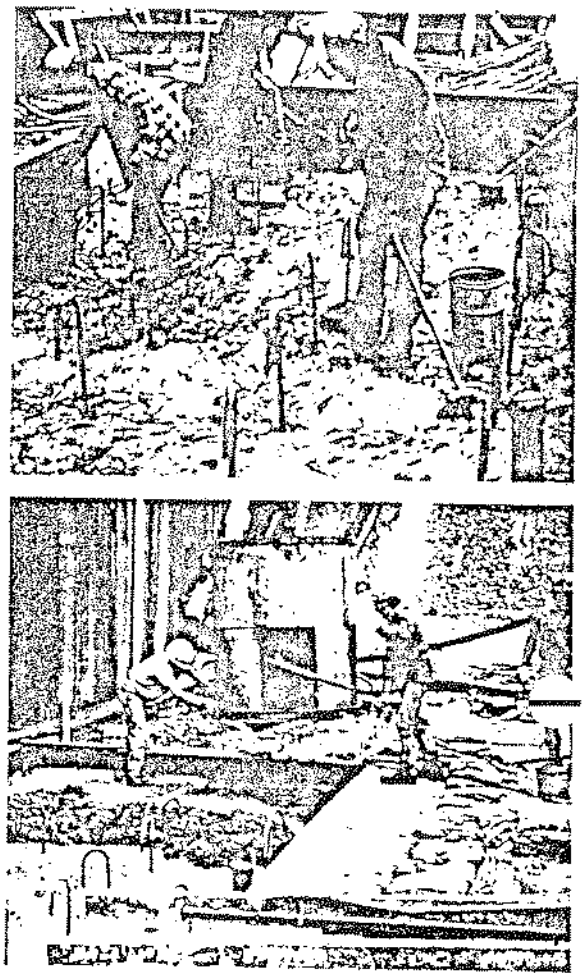
PROPORTIONING/MIXING: Store or bring material temp to approx 75F to facilitate mixing and application. Stir components before proportioning. Volumetric ratio of Sikadur Hi-Mod is 1:1 (B:A). To mix, proportion equal parts A and B components into clean pail. Mix thoroughly for 3 minutes with Sika paddle on low-speed (400- to 600-rpm) drill until blend is a uniform color.

APPLICATION: To bond fresh to hardened concrete, apply neat Hi-Mod to substrate with stiff-bristled broom to thickness of approx 20 mils; place concrete.

Hi-Mod may be sprayed over reinforcing steel and concrete substrate. Consult Sika representative for details.

LIMITATIONS: Do not thin Sikadur Hi-Mod. Solvents will prevent proper cure.

Substrate temperature must not be below 40F. Exposure to elevated temperatures for prolonged periods is not recommended: contact Sika Technical Service for details.



CAUTION: Contains epoxy resins and organic amines. Toxic before cure... avoid inhalation of vapor and contact with skin or eyes.

Read page 70 thoroughly before use.

Figure 74

2. Mortar

The 3:1 sand:cement ratio currently in use provides a good physical match to the original material. The use of Acryl 60 at 10% of mix water may be continued if found helpful to workability and adhesion. Tests on mortar cubes prepared to this formula have shown that it does not impair the performance of Chemtrete BSM-40R, the recommended water repellent. Stronger concentrations of Acryl 60 should not be used. To further improve the workability of the mortar, and to reduce shrinkage we recommend addition of 1/10 part of hydrated lime to the mortar mix. The proportion may be increased up to 1/4 part, but only if Acryl 60 is eliminated from the mixing water. Mixes may be modified within these limits to find the optimum mix for specific conditions and applications.

The importance of accurate gauging of mortar mixes cannot be stressed too highly. Water quantities, too, should be carefully controlled, taking account of moisture content of sand, and using just enough to achieve thorough hydration and workability. The lime will help reduce water required to achieve a workable mix.

The present practice of brushing the surface of the repair to match the appearance of Rodia's mortar should be continued. Where appropriate, mortar pigments should be used to match the color of the original mortar.

3. Adhesives/Caulking

The presence of extensive, potentially dynamic cracks due to thermal or wind movement and the existence of large quantities of loose ornament dictate the need for a reliable sealant or adhesive material. Criteria for the adhesive should be as follows:

--elastic modulus below that of mortar or tile;
--compatible with preferred waterproofing;
--guaranteed life of 15-20 years;
--ease of application;
--solvent reversible for removal or future replacement.

Criteria for the sealant should be as follows:

--able to fill cracks ranging from 1/4 to 1 inch;
--moderate to high peel strength (25-30 lbs.);
--maximum elongation (50-300%);
--durable (average life 15-20 years);
--easy to apply (one part material);
--compatible with preferred waterproofing;
--extensive color range.

The test program for caulking materials undertaken by Twilley and Goldstone provides valuable information on the performance of five of the best available sealant materials. Several of these materials are "sealant/adhesives," and thus would be suitable for adhering glass and tile as well.

Many questions remain, however, about the actual performance of these materials under the unique conditions present at the Towers. The existing cracks are by no means as uniform as those used by the manufacturers and by Twilley & Goldstone in evaluating the capabilities of the materials. At the same time, labor is the single most expensive item in the repair budget, and past experience has proven that recommended procedures must be extensively modified to fit job conditions. Answers to these issues are important not only to ensure that the present repair program is adequate and economical, but also because they will become critical items in future maintenance programs.

There is clearly a need for on-site testing, yet repairs must continue as rapidly as possible. Under the circumstances, we therefore recommend that the three materials which perform best under the criteria above--Tremco DYmeric, Sikaflex 1a and Dow 795--be tested as part of the continuing repair program, as follows:

. Select a representative sampling of each type of repair condition (crack widths, materials to be joined, etc.) for use with each of the three materials.

. Record repair procedures as at present, noting the type of material used and any problems encountered in application as well as any departures from manufacturer's recommended methodology.
. Monitor repairs after six and twelve months. Based on appearance, service and effects on surrounding materials, select final method to be used for repair and maintenance. In the interim, if caulking is to proceed, use one material of the three only.

The value of this program will be three-fold:

. It will provide the only reliable indication of actual service on the Towers;

. It will supply the only accurate measure of the actual cost of application; and

. It will establish a system under which more advanced materials can be evaluated in the future.

This program was recommended in August 1982, and carried out subsequently by Ward Treadwell. The conclusion of these on-site trials is that the silicone based Dow Corning 795 sealant performs best. This is the same material we recommended for re-adhering individual fragments of ornament. Note, however that caulking of joints should not be seen as a permanent solution to cracks found on the towers, particularly large vertical cracks which inevitably signal terminal corrosion of the armature. They should be used to prevent water ingress until a proper repair can be made. Where cracks are large, polyethylene foam backer rod should be used and the members should be strapped as a precaution.

4. Replacement of Ornament.

Ornament used on the Towers can be characterized as:

- highly specific - e.g. statuary, impressions of cast or wrought metal, SR's implements, etc.

- specific - e.g. glazed pottery, mirror, etc, where a particular effect is sought of color or texture using a specific medium.

- generic - e.g. seashells, broken bottles, colored mortar.

The revised general criteria (see pp. 135-138) permit the replacement of ornament in contradistinction to earlier repairs by the Office of the State Architect. We recommend that the following criteria should guide the replacement of ornament.

- Where highly specific ornament is available, and its precise location and type is known, it should be replaced. It may even be replicated if the original is not available (e.g. bowling ball, impression of wrought metal used elsewhere from which a copy could be made in plaster).

  If doubt exists about original highly specific ornament, it shall not be replaced. In any case all work done involving highly specific ornament MUST be recorded in full in the repair booklet with before and after photographs.

- Specific ornament may be replaced using only the stockpile of original Rodia materials, and only to complete an area of known pattern and color to approximate the original. Once again all work is to be fully recorded.

- Generic ornament may be replaced using newly obtained material. This includes common glass, seashells and mortar coloring. Every effort should be made to achieve color and overall texture and pattern match with the original. All work is to be fully recorded.

For all three types of ornament replacement, the repair specifications are to be fully complied with.

5. Identification and Recording System.

The current system of location, notation, repair logs, written descriptions and progress photographs are admirably thorough. We recommend that the following improvements be incorporated:

a. Institute a permanent system of tagging tower members in order to facilitate reference and recording during present repairs and future maintenance. We suggest using plastic tags 1 inch wide by 5-6 inches long, with incised, contrasting-color lettering 3/4" high. (Fig. 75) Holes should be drilled at each end of the tag so that it can be fixed to the member with stainless steel wire or marine-grade polychord to

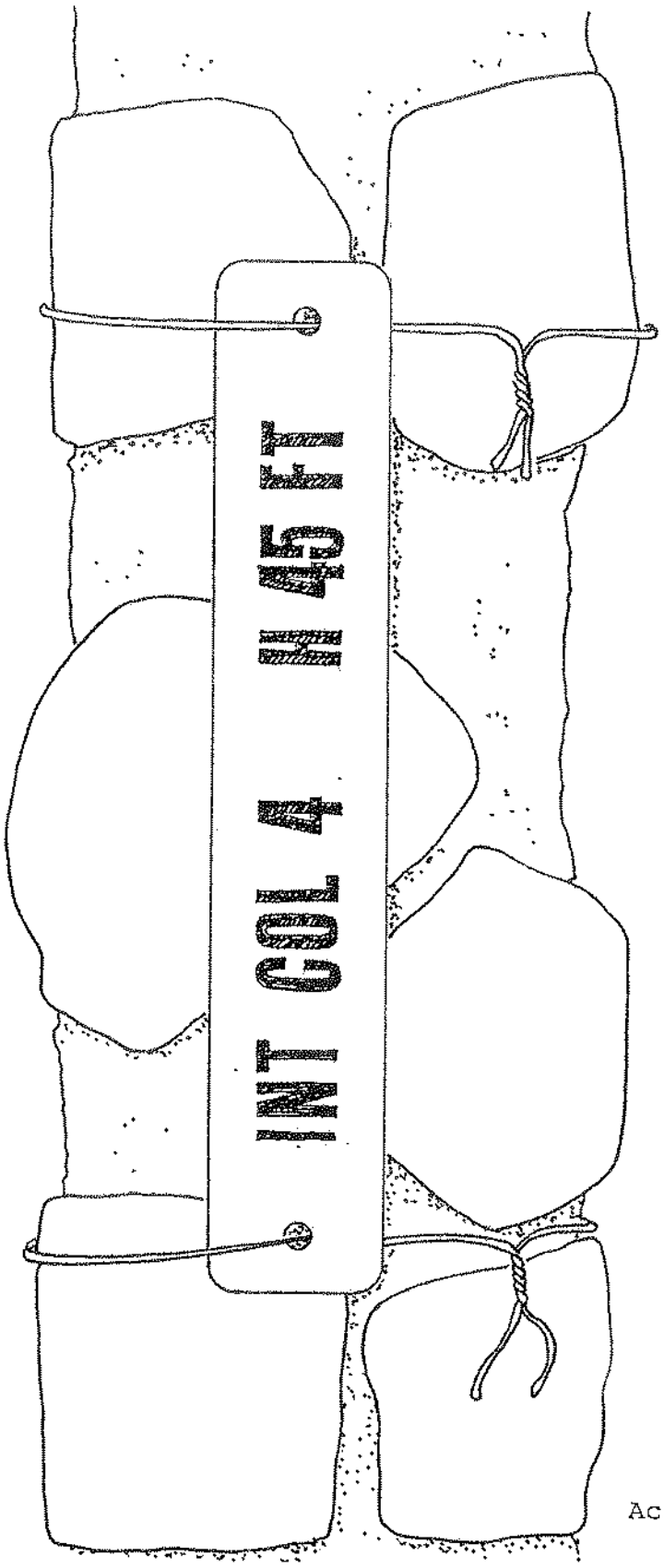


Figure 75

Actual size

Identification Tags

prevent movement or displacement. Color and placement of the tags should be such that they do not constitute a visual intrusion, yet are clear enough to be read through binoculars during maintenance inspections. A Tag Engraver, 3/4" font, cutter, and supply of precut plates (Phenolics would be suitable for outside use) should cost no more than $500.00. Scott Machine Development Corporation's Tag Engraver, Cat. No. SM 100B would be suitable.

b. Incorporate repair numbers and location codes in record photographs, using a chalkboard or other sign that can be hung adjacent to the repair area. The board should include a foot and metric scale along one side. This will prevent confusion should negatives or prints be mixed up, and can serve as a scale reference.

c. The present photographs, taken with an "Instamatic" camera, generally do not provide clear detail. A 35 mm camera with automatic exposure but variable focus and depth-of-field should be provided, and all crew members should be instructed in its use.

d. Color film is not archivally stable, but in the interest of efficiency and accuracy in restoring the original finishes, we recommend that use of Kodachrome film, the most stable of the color films, be continued. Black and white film processed to archival standards may be used to duplicate the recording method if archival stability is considered a requisite.

D. RECOMMENDATIONS FOR FURTHER RESEARCH

One large-scale problem which is not being dealt with under current repair procedures is the filling of cracks smaller than 1/4"-1/2" wide. Since solid sealants cannot be used for such small fractures, an injectible adhesive or sealant must be employed. Such a material should combine:

--low viscosity, to permit the material to penetrate the narrow crack and

--high flexibility, to ensure that continued movement as well as the presence of a more rigid material does not cause destruction of original material.

Use of an epoxy injection grouting system has been proposed to fill this need, and indeed has been attempted at the Towers in earlier repair campaigns. It poses a number of potential hazards, however:

1. Use of any pressurized injection system may cause further cracking in fragile, adjacent members.

2. Due to non-uniform construction of the Towers, grout penetration and curing may be difficult to determine.

3. Use of penetrating grout may fill voids currently serving to absorb differential expansion and/or corrosion of the reinforcing.

4. Use of epoxy grout places a permanent new matrix in Tower elements, which may create problems in carrying out future repairs.

In addition to the risks of epoxy grouting for the structure, it presents application difficulties. The machine used to mix the components and deliver them under pressure is quite large (i.e. about the size of a 2 drawer filing cabinet) and must be very close to the work, which is often impossible on the towers.

Therefore we do not recommend further research into epoxies for use on the towers, at this time.

It remains incumbent upon those responsible for repair and restoration, however, to be alert for improvements and developments in repair technology that might, after careful testing, enhance the longevity of the towers.

PART TWO:
PRESERVATION PLAN

IV. RECOMMENDED TREATMENT OF UNREPAIRED DAMAGE

IV. RECOMMENDED TREATMENT OF UNREPAIRED DAMAGE

A. REVIEW OF CURRENT STATE-OF-THE-ART CONSERVATION TECHNOLOGY

The repair and maintenance of Watts Towers is obviously a unique problem, requiring a carefully-researched set of solutions. A number of available technologies have therefore been reviewed and compared with those currently used or proposed with a view towards their feasibility for use at the Watts Towers. They represent as many different options as could be suggested, and range from complete enclosure to complete replication.

1. Enclosure.

The only means of preventing further deterioration of the existing reinforcement and concrete cover would be to prevent contact with moisture, and the only way to accomplish that end is through complete enclosure. Pearce Structures (formerly Synestructics, Inc.) of Chatsworth, California was requested to prepare a proposal for a space frame enclosure for the Towers. This is to be pursued by CSRTW.

Unfortunately, enclosure will not prevent all future conservation problems. First, it will have no effect on damage due to earthquakes, which will take place regardless. Second, unless the interior environment is carefully controlled, build-up of heat and humidity within the enclosure can actually increase cracking due to thermal movement and subsequent corrosion.

The most serious objections to the construction of an enclosure are aesthetic and philosophical. The Towers inspire awe through their intricacy of design. Their significance and full appreciation depends on access to viewing at all angles and from afar. Enclosure would preclude this experience, as well as cutting the Towers off from the context of the surrounding community.

2. Replication in Stable Materials.

Because the Towers as presently built will continue to corrode and spall upon exposure to the atmosphere, the only permanent alternative to enclosure is rebuilding in stable materials. This procedure would require the following:

a. Complete, piece-by-piece documentation through photogrammetry and rectified photographs.

b. Identifying all ornament with location numbers based on present OSA nomenclature, and matching numbers to photographs and drawings to show exact position of ornament.

c. Making casts of decorative impressions in mortar on thin columns. Careful cutting and removal of large panels of impressed concrete on walls, etc.

d. Detachment of all ornament, column-by-column or band-by-band, and storage in labelled containers. Elements broken during dismantling should be re-adhered immediately. All ornament should be cleaned of old mortar before storage. Ornament too seriously damaged to be salvaged should be noted on photos or drawings.

e. Document armature as it is exposed.

f. Demolish armature.

g. Prepare reconstruction documents. Armature should be constructed of stainless steel bars, angles, wire and mesh. Design should duplicate dimensions and configuration of original, withstanding calculated lateral and gravity loading. Design of joints between horizontal and vertical members and all other parts should be designed to accomodate lateral movement and thermal expansion.

h. Steel armature should be primed with concrete bonder. Mortar matching original in color texture and finish should be applied to the armature in layers to the original thickness, using best available materials and methods. Incorporate expansion joints as required.

i. Apply ornament to fresh finish mortar coat. Position should match that of original ornament. In areas where ornament was too damaged to salvage, matching new ornament should be supplied.

j. Apply water repellant coating to all surfaces. Coating selected should be compatible with mortar and ornament and cause no visible changes in surface color and texture.

While initially very expensive, this method might prove most economical, given the anticipated periodic repair costs. It must be noted, however, that even the most durable materials have a finite lifespan, and will eventually require repair and/or replacement. There are numerous precedents for replication of historic structures and sculpture. In eastern Europe, entire historic districts were reconstructed following the devastation of World War II bombings. On the Acropolis in Athens and the Piazza San Marco in Venice, important sculptures have been removed from the corrosive atmosphere to museums, with plaster casts substituted to preserve integrity of the architectural whole.

Closer at hand is the Palace of Fine Arts in San Francisco. Constructed of plaster on wire lath for the 1915 Panama-Pacific International Exposition, the structure was only intended to stand for the duration of the fair. Popular demand preserved the Palace of Fine Arts after the other Exposition buildings had been demolished, but decades of rain caused extensive deterioration. Just as the structure was about to be condemned in the 1950's, funds were donated for its replication in reinforced concrete, following the original construction documents prepared by Bernard Maybeck.

Watts Towers is nonetheless quite different from the Palace of Fine Arts and the Parthenon. Fundamentally, it is a sculpture rather than a building. Its specific form and location are important factors in its significance, so that removal from the site would alter its character. The real interest and beauty of the Towers, however, is in the fact of their creation, in Simon Rodia's decades-long, painstaking work. To replace Rodia's handiwork with that of a construction crew, however skilled they may be at reproducing his art, would be to destroy the major part of its significance.

3. Cathodic Protection.

If enclosure and replication pose philosophical and physical limitations, cathodic protection offers an alternative to preserving the original structure in situ. For the past two decades, considerable success in the prevention of corrosion in deep-sea oil drilling rigs, highway bridges and pipelines has been acheived through the use of cathodic protection. The procedure essentially "short circuits" the corrosion process, which begins when iron is exposed to moisture and oxygen. By definition, metals lose electrons under such conditions and pure iron (Fe) combines with the oxygen and water to form ferric hydroxides (FeO) and hydrated ferric oxide ($Fe_2(OH)_3$)--known as rust. Given the presence of sufficient air and moisture, this process continues until all the iron or steel has been consumed.

With cathodic protection, a direct electrical current is induced within the structure. The steady supply of electrons depresses the steel-to-concrete voltage potential, preventing the iron from contributing its electrons and thus impeding corrosion.(12) Relatively little current is required; some severe attacks have been stopped by a potential of about -1 volt.(4)

With regard to use at Watts Towers, cathodic protection is difficult to develop as a retrofit. The primary problem is that of controlling the voltage potential and current densities over the entire surface of the reinforcing steel. Excess voltage can cause softening of concrete in the vicinity of the steel and reduction of bond strength; discontinuities can increase the galvanic potential and thus actually accelerate corrosion.(3)

Clearly, the existing armature of Watts Towers is not consistent enough to furnish cathodic protection. The reinforcement is of varied sizes and conditions, the joints between pieces are of uncertain configuration and the presence of large amounts of stainless steel and other metals makes uniform current transmission virtually impossible.

4. Water Repellant Coatings.

Water repellant coatings have been suggested for use on the Towers, the reasoning being that by decreasing water absorption within the concrete matrix, the coating would thereby reduce corrosion of the reinforcement and spalling of the concrete. In order to assess the value of water repellant coatings in general and particular products in relation to each other, it will be useful to outline how coatings act on concrete, advantages and disadvantages of coatings systems, and criteria for their use at Watts Towers.

First, the difference between waterproof and water repellant solutions should be explained. A waterproof material is "an impervious coating, e.g. coal tar, asphalt and some paints, which seals the surface to the infiltration of water." A water repellant, by contrast, "penetrates the surface and permits the movement of water vapor but not the infiltration of water." (1) Waterproof materials are not suitable for use at the Towers for the following reasons:

-- The surface coating will alter the appearance of the sculpture.

-- There will always be a certain amount of moisture present within the masonry, either already present or penetrating through cracks. When heated, this moisture will attempt to escape as water vapor. The resulting buildup of moisture and pressure, as well as any salts migrating with the water, behind the coating will cause the coating to crack and peel. If adhesion of the coating is sufficient, such peeling may take parts of the substrate with it.

Thus, only water repellants will be considered in this discussion.

Water repellant solutions typically consist of a solution of oils, salts, resins or other solids in a solvent. They are applied to the masonry surface with a spray, brush or total immersion, where feasible. They develop water repellant capacities as the solvent evaporates, depositing the dissolving materials as a film within the pores of the matrix. The depth of penetration, the type of bond between coating particles and the matrix, the resistance to water absorption and water vapor transmission and the performance of the material under exposure to the weather--critical factors in the success of the coating--are all dependent upon the formulation of the solution.

In the past decade, a number of studies on available water repellant materials have been carried out. (1, 5, 9) Focus of the research has been not only on actual performance of the materials, but on developing test standards that provide a reliable indication of how the material will perform in actual service. Recently, Twilley and Goldstone (11) have attempted to use these methodologies to evaluate four water repellant materials applied to mortar from Watts Towers. Representing the best and the most commonly available materials, these are described below, with a summary of the test results.

a. Wacker H is a "reactive alkoxy-silane" (11) consisting of polymethyl silicic acid (silicone resins) in a solution of 50-56.6% solids. (1) Clifton and Frohnsdorff give the following explanation of silane chemistry:

> Three alkoxysilanes are commonly used to consolidate stone. They are tetraethoxysilane and trimethoxymethylsilane. Tetraethoxysilane is an example of a silicic acid ester. Their polymerization is initiated by a hydrolisis reaction,
>
> $$Si - OR + H_2O \text{ ---------- } SI - OH + ROH$$
>
> Then polymerization commences:
>
> $$Si-OH + Si - OR' \text{ ------- } SI-O-Si + R' OH$$
>
> where R = CH_3 (methyl) or C_2H_5 (ethyl) and R' = H, CH_3 or C_2H_5.
>
> Polymerization continues until all the alkoxy groups have been liberated and either an alkylpolysiloxane or silica is produced. Silica is produced by the polymerization of a silicic acid ester. An alkylpolysiloxane is formed the polymerization of other types of alkoxysilanes.

The three silicon-oxygen linkages impart a measure of strength to the matrix (12, 13) and strength increases in stone of as much as 20% have been reported. (2) The alkyl radical reacts with the stone surface, changing the interfacial forces and actually making the surface repellant to water. (6) The material appears to form a continuous coating around the stone grains. (2) Thus, it excludes water not by sealing the pores, but by rendering them hydrophobic. As a result, water vapor transmission remains largely unchanged.

Alkoxysilanes as a rule are better penetrants than most water repellants. The small size of the silane molecules, coupled with their solubility in polar, water compatible solvents, enables the solution to penetrate deeply into the micropore structure of the stone or concrete. (6) Penetration depths of nearly 2 inches have been reported. (2)

b. Chemetrete BSM is also an alkoxysilane material, with solids dissolved in ethyl alcohol, and acts in a similar manner as Wacker H.

c. Chemstop Regular Masonry Waterproofing is a solution of resins--"acrylate", aluminum stearate and oil--in a hydrocarbon solvent at a concentration of 6.8% solids. According to the manufacturer, the material forms (first) a water repellant surface film when the solvent evaporates; (second) a "gel-like film" that line pore walls, "blocking ordinary capillary action;" and (third) reacts chemically with constituents in the substrate to create a barrier that is an integral part of the material.

The primary active ingredient is the acrylic polymer. According to Clifton and Frohnsdorff,

> Where deep or complete impregnation and complete polymerization was acheived, methylmethacrylate and other acrylates have been shown to improve substantially the mechanical properties and durability of porous materials such as concrete. However, incomplete impregnation with acrylates may result in the formation of a distinct, probably undesirable, interface between treated and untreated stone. ...Unless very dilute solution are applied to the stone, solvent evaporation will tend to draw the acrylic copolymers back to the surface. Then, even if diluted to the lowest concentration that will give some consolidation, their solutions still may have high viscosities which will impede their penetration into stone.

d. Hydrozo Clear 15 is, according to the manufacturer, a "modified oil material making a mineral gum, in formula with a volitile thinner." It is composed of aluminum stearate and oil in 6.8% solids. Aluminum stearate is an inorganic compound, a class of water repellant which was frequently used in the 19th and early 20th centuries. Typically, these materials act by simple precipitation of the compound within the voids and pores of the stone, or by chemical reaction of the liquid with the stone. According to Clifton and Frohnsdorff:

> Little success has been acheived in consolidating stone with inorganic materials, and in some cases their use has greatly accelerated stone decay. Some of the reasons given for the poor performance of inorganic consolidants are their tendencies to produce shallow and hard crusts, the formation of soluble salts as reaction by-products, growth of precipitated crystals, and the questionable utility of some of them to bind stone particles together. Of these, the most difficult problem to overcome is the formation of shallow hard surface layers by inorganic consolidants because of their poor penetration abilities. Precipitation processes are often so rapid that precipitates are formed before the inorganic chemicals can appreciably penetrate the stone.

e. Test Results

The experimental program developed by Twilley and Goldstone was designed to test the following criteria: (1) high water repellancy; (2) compatibility between water repellants and joint sealants; (3) maximum permanence; (4) reversability and reworkability; and (5) no formation of water vapor barriers. The four water repellants listed above were applied to 48 specimens of Watts Towers mortar that had been constructed with joints filled with sealants. After curing, specimens were subjected to 100 and then 500 hours exposure in a weatherometer.

In terms of reducing absorption, results were as follows (p. 13):

Material	% Reduction in Water Absorption After 500 Hours
Wacker H	77.23
Hydrozo Clear	64.97
Chemtrete BSM-40R	56.81
Chemstop	69.99

The authors noted that if anomolous samples for Chemtrete were discarded, the reduction in average water absorption would have been greater than Hydrozo. They also remarked that Wacker and Chemtrete, the alkoxysilanes, "acheive a more effective treatment across the full range of specimens that the other two materials."(p. 6)

In terms of compatibility between water repellant and sealant, Twilley and Goldstone noted, "we found no evidence to indicate that any of the elastomers was detracting from the performance of any repellant"(p. 7) and vice versa.

The test procedure does not appear to have measured water vapor permeability.

Data from additional tests on the performance of these and related water repellant materials can be found in Section IV.B.1.

f. Criteria for Use at Watts Towers

Any water repellant material to be used at Watts Towers must meet a number of criteria formulated to ensure that its physical and artistic integrity are preserved. In addition to those proposed above by Twilley and Goldstone, we would recommend the following:

- Should dry to tack free finish to prevent dirt from settling on surface;
- Must penetrate masonry surface to sufficient depth to ensure long-lasting effect and avoid crust formation;
- Should not alter color of masonry surface;
- Should be resistant to UV and not discolor through weathering influences.
- Must not attack chemistry of embedments e.g. glass, glazes
- Must be alkali resistant.
- Should not be sensitive to water content of matrix during application.

Even if a material can be found to meet all these criteria, one must still recognize a number of limitations related to use at the site:

--None of the materials will fill cracks larger than capillaries, although the demonstrated ability of silanes to "bridge" fine cracks is a great advantage.

--Where cracks remain and water can penetrate to the metal armature, use of a water repellant coating can accelerate corrosion rather than inhibiting it. This propensity will be enhanced on the Towers because of their exceptionally high surface-to-volume ratio compared with conventional structures. Because the surrounding surface mortar is hydrophobic, water which might evaporate before reaching the core of untreated sections will be channelled directly to the metal.

--Curing of cement in future repairs and bond to treated original material may be seriously affected, since water absorption in surrounding material is inhibited.

--With the exception of Chemetrete, all manufacturers of water repellant materials recommend cleaning or protecting glass surfaces from the coating. Given the large amounts of glass and glazed ornament on the Towers, such tasks must be added to the cost of coating.

--As Gerald Stanley suggests in a letter of August 5, 1982, single coat application as recommended by all manufacterers except Hydrozo, may allow applicators to miss spots on the surface, thereby allowing water penetration.

Considering all these criteria and limitations we have conducted further tests on the materials tested by Twilley and Goldstone. As a result we recommend application of Chemtrete BSM-40R in a single spray coat application. Application should only be made to a substantially repaired component of the Towers (e.g. a whole tower), following all other repair procedures. Chemtrete performs well in bridging capillaries, does not affect glass or glazing, is not affected by the 10% Acryl used in mortar mix water, and will contain a fugitive dye which lasts 3 days to indicate clearly application "holidays" and extent of application. As far as the risk of water entering cracks is concerned, that is dependent on the thoroughness of the repair program to ensure that no significant cracks remain prior to coating. Coating should not take place while cracks are still being closed by temporary caulking and bonding.

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B. LABORATORY AND ON SITE TESTING

1. Water Repellant Coatings

Early in 1982 John Twilley conducted a useful series of tests on water repellants and crack filling elastomers for potential use on the Towers. The results are discussed in the preceding section. Since then we have conducted further tests on the four water repellants using the procedures developed by Wiss, Janney Elstner and Associates Inc. in their recent work for the Transportation Research Board. The objective was to evaluate the efficacy of the tested sealers in protecting concrete against the ingress of water, and their effectiveness as chloride screens.

Until recently there have been few systematic well controlled tests of water repellants, to yield generally useful comparative information. Product composition may be modified by manufacturers and the historic material which it is intended to coat is seldom accessible to the laboratory. Twilley's work is valuable in that it was done on actual samples from Watts Towers, but we were concerned to compare the products with respect to two attributes he did not study, water vapor permeability and the effectiveness of the water repellants as chloride screens. Water vapor premeability is important because it governs the rate at which water trapped behind the repellant (either before its application or having entered cracks too large to seal) can evaporate into the air. Chloride screening is important because chlorides accelerate corrosion of the armature and an important function of the water repellant is to inhibit transportation of chloride into the mortar whence it can reach the steel.

In Wiss Janney Elstner's original work only Chemtrete BSM-40 was tested among the products also tested by Twilley. Our objective, on the advice of WJE was to subject all the products tested by Twilley to some of the tests devised by WJE, using identical concrete samples and procedures to those used in their original work. This allowed us to corroborate Twilley's results by comparison with WJE's and to locate Hydrozo, Chemstop, and Wacker, not orginally tested by WJE, within the spectrum of results they obtained for a wide range of chemical formulations.

The first step in this process, was to soak 2 4" concrete cubes coated in each of the materials in a 15 percent Na Cl saltwater solution for 21 days, and to measure water absorption as weight gain compared with uncoated cubes.

Subsequent tests measured water vapor transmission during air drying and chloride content gain compared with water absorption. The material we sought would allow more water to pass than chloride ion.

Based on Wiss Janney Elstner's analysis, the most successful of the water repellents tested was Chemtrete BSM-40R, which they also describe as possessing "moderate chloride screening capabilities."

To confirm these findings on the repair mortar currently being used, rather than on the standard concrete cubes used by Wiss Janney, and to assess the consequences for water repellance of continued use of 10% Acryl 60 mix water, 15 2" cubes were made by Ward Treadwell and sent to the Dynamit Nobel laboratory, manufacturers of Chemtrete. Three different Chemtrete formulations were used to coat 9 of the cubes, BSM-40R, BSM-40H, and BSM-40V. The latter two are formulations intended for masonry and stone consolidation respectively, and they performed marginally better than the BSM-40R in Dynamit Nobel's absorption test, however they should not be used at Watts Towers because they will damage glass and glazing. BSM-40R performed satisfactorily, allowing for a lower coverage rate than in the WJE test, and the effect of the Acryl 60 in the mix appears to be negligible at the 10% of mix water concentrations.

Wiss Janney Elstner's and Dynamit Nobel's reports follow.

INVESTIGATION OF SEALERS

ON

PORTLAND CEMENT CONCRETE

FOR

THE EHRENKRANTZ GROUP, P.C.

WJE NO. 820650

December 15, 1982

Wiss, Janney, Elstner and Associates, Inc.

INTRODUCTION

At the request of Mr. Andrew Rabenack of The Ehrenkrantz Group, P.C., the firm of Wiss, Janney, Elstner and Associates, Inc. (WJE) has tested seven different types of sealers as a protective coating for concrete construction. Six tested materials were supplied by Mr. Ward Treadwell of California Parks and Recreation and were identified as: Hydrozo Clear 30, Hydrozo Clear Double 7, Hydrozo Clear 15, Chemstop Heavy Duty, Chemstop for Concrete, and Wacker Silicone. A sample of Chemtrete BSM-40 was sent to WJE from the manufacturer in New Jersey.

The objective of this extensive laboratory study was to evaluate the efficacy of the tested sealers in protecting concrete against the ingress of chloride-laden water. These tests were based upon testing techniques developed and used by WJE in the NCHRP Report No. 244, "Concrete Sealers for Protection of Bridge Structures". The tests evaluated the following parameters:

- Water absorption - desorption characteristics of sealed concrete
- Chloride ion penetration into sealed concrete
- Water vapor transmission characteristics of sealed concrete

DESCRIPTION OF TEST PROGRAM

Materials

The following materials were used in this investigation:

Sand:	Natural river sand (chloride free)
Coarse aggregate:	Natural rounded river gravel (chloride free)

Both of these materials were obtained from the American Materials Corporation, Eau Claire, Wisconsin.

Portland cement:	Type 1
Air-entraining agent:	Neutralized, vinsol resin
Sealers:	Hydrozo Clear 30 Hydrozo Clear Double 7 Hydrozo Clear 15 Chemstop Heavy Duty Chemstop for Concrete Wacker Silicone Chemtrete BSM 40

Concrete Mix Design

The concrete was designed to have a 28-day compressive strenth of approximately 4500 psi, with a w/c ratio of about 0.50, air content of

about 6 percent and a slump of approximately 3 in. The significant properties of the fresh and hardened concrete were as follows:

	S.S.D. quantities/yd^3
Cement content, lb	444
Coarse aggregate content, lb	1495
Sand content, lb	1705
Water content, lb	225
Plastic unit weight, pcf	143.3
Air content, percent	6.4
Net w/c	0.51
Slump, in.	2.5
Average 28-day compressive strength, psi	4370

Casting, Curing and Coating Procedures

All tests were made on duplicate 4-in. concrete cube specimens. The forms used for coating the cubes were constructed of a special resin-coated wood to preclude the need for any release agent which might chemically contaminate the concrete surfaces during casting.

The wooden gang forms were table-vibrated using two lifts of concrete. Each 2-in. lift was vibrated for 30 seconds. As shown in Fig. 1, the top surfaces were then finished with a wooden float and covered with polyethylene film for overnight curing at 70°F. Specimens were stripped at the age of 1 day and placed within sealed heavy-duty plastic bags for moist-curing in the controlled climate room. At the age of 7 days, the cubes were lightly sandblasted and then returned to

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the plastic bags. The cubes were stored in these plastic bags for several months. They were removed from the plastic bags and placed in the controlled climate room on steel racks for air drying at 70°F and 50 percent R.H. for 5 days before the sealers were applied. As shown in Fig. 2, each material was applied by brush to two concrete cubes. One pair of uncoated concrete cubes served as control specimens. The amount of each material applied to each cube was calculated using the weight of the material in lbs per gallon and the surface area of the cube. The application rates were as follows:

Material	No. of Coats	Coverage (ft^2/gal)
Hydrozo Clear 30	1	100
Hydrozo Clear Double 7	1	100
Hydrozo Clear 15	1	100
	1	125*
Chemstop Heavy Duty	1	40
	1	80**
Chemstop for Concrete	1	100
Wacker Silicone	1	≈60
Chemtrete BSM-40	1	125

* The second coat was applied after 24 hours
** The second coat followed the first coat

Testing Procedure

After coating, the cubes were returned to the controlled climate room for 14 days of curing of the sealant materials. The cubes were

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then immersed in a 15 percent NaCl solution for 21 days. As shown in Fig. 3, the cubes were placed in covered plastic containers and the tops of the cubes were about 1 in. below the surface of the water and salt solution. After 21 days of soaking, the cubes were again stored in the climate room at 73°F ± 3°F and 50 percent R.H. for 21 days to observe water vapor transmission characteristics (see Fig. 4). During the 21 days in the salt solution (soaking period) and in the climate controlled room (drying period), the gain in weight and the weight loss at 3, 7, 14 and 21 days were determined to the nearest 0.1 gram.

Following the final air-drying period, each cube was then mechanically split in half. One half was crushed and the total chloride ion content was determined using an acid digestion, potentiometric titration procedure. The second half of each cube was retained.

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RESULTS AND DISCUSSION

The weight gain and weight loss data during the soaking and air-drying periods are given in Table 1 and are depicted graphically in Fig. 5. The results from measuring the total chloride ion content of these sealed concretes, following the soaking and air-drying periods, are given in Table 2.

As shown in Table 1, large differences were found in the weight gain and loss data between the two cubes which represented one sample in all the specimens except those coated with Hydrozo Clear Double 7. With four materials (i.e., cubes treated by Hydrozo Clear 30, Hydrozo Clear 15, Chemstop Heavy Duty and Wacker Silicone), one cube gained less than 1 percent by weight of water while the second cube gained two or three times as much water by weight of concrete after 21 days of soaking.

When compared to the uncoated concrete specimen, the sealers reduced the total weight gain as follows:

Name of Product	Reduction of the Total Weight Gain (%)*		
	From	To	AVG
Hydrozo Clear 30	72	38	55
Hydrozo Clear Double 7	26	19	23
Hydrozo Clear 15	70	14	42
Chemstop Heavy Duty	65	18	42
Chemstop for Concrete	44	27	36
Wacker Silicone	77	29	53
Chemtrete BSM-40	74	58	66

*As compared to uncoated control cubes

These average data show that these seven materials reduced the water gain by as little as 23 percent to as much as 66 percent. The final residual weight change data shows that none of the seven coated specimens lost more weight by vapor transmission during the final air-drying period than they had gained during the soaking period.

As shown in Table 2, large differences were also found in the chloride ion content between the two cubes which represented one specimen. The percent of chloride ion by weight in the original 15 percent NaCl water solution was 9.2 percent. Values for the actual percentage of chloride ion absorbed have been obtained by subtracting the 0.007 percent by weight of chloride found in the untested control concrete. Values of adjusted chloride ion content, weight gain and weight loss, and the calculated values for the apparent strength of the chloride solution which penetrated into the specimens are summarized in Table 3. These data seem to indicate moderate chloride screening capabilities for Hydrozo Clear 30, Hydrozo Clear 15, Chemstop Heavy Duty and Chemtrete BSM-40.

TABLE 1 - WEIGHT CHANGE DURING SOAKING AND DRYING PROCESS

Name of Product	Coverage ft^2/gal	Weight Change After Days of Soaking (%) 3 Ind.	3 AVG	7 Ind.	7 AVG	14 Ind.	14 AVG	21 Ind.	21 AVG	Net Weight Change After Days of Air Dyring (%) 3 Ind.	3 AVG	7 Ind.	7 AVG	14 Ind.	14 AVG	21 Ind.	21 AVG
Hydrozo Clear 30	100	0.38 0.79	0.58	0.45 1.16	0.81	0.65 1.41	1.03	0.67 1.51	1.09	0.40 1.20	0.80	0.30 1.02	0.66	0.23 0.85	0.54	0.18 0.72	0.45
Hydrozo Clear Double 7	100	0.67 0.74	0.71	1.06 1.15	1.11	1.68 1.74	1.71	1.81 1.97	1.89	1.46 1.61	1.53	1.14 1.26	1.20	0.90 1.01	0.96	0.76 0.85	0.81
Hydrozo Clear 15	100/125	0.38 0.97	0.68	0.48 1.58	1.03	0.65 2.03	1.34	0.72 2.10	1.41	0.47 1.78	1.13	0.38 1.56	0.97	0.28 1.29	0.79	0.21 1.08	0.65
Chemstop Heavy Duty	40/80	0.50 0.83	0.67	0.70 1.33	1.02	0.84 1.88	1.36	0.86 1.99	1.43	0.58 1.69	1.14	0.46 1.40	0.93	0.35 1.14	0.75	0.27 0.96	0.62
Chemstop for Concrete	100	0.56 0.71	0.64	0.94 1.19	1.07	1.28 1.59	1.44	1.36 1.78	1.57	0.99 1.49	1.24	0.79 1.13	0.96	0.63 0.92	0.78	0.53 0.78	0.66
Wacker Silicone	60	0.32 0.84	0.58	0.41 1.29	0.85	0.56 1.72	1.14	0.56 1.72	1.14	0.23 1.52	0.90	0.17 1.35	0.76	0.13 1.15	0.64	0.08 0.98	0.53
Chemtrete BSM-40	125	0.29 0.44	0.37	0.41 0.66	0.53	0.58 0.94	0.76	0.63 1.02	0.83	0.27 0.57	0.42	0.22 0.48	0.35	0.18 0.40	0.29	0.14 0.33	0.24
Plain Concrete	0	2.13 2.38	2.26	2.21 2.44	2.32	2.26 2.50	2.38	2.29 2.56	2.43	1.78 2.04	1.91	1.38 1.65	1.52	1.10 1.34	1.22	0.93 1.15	1.04

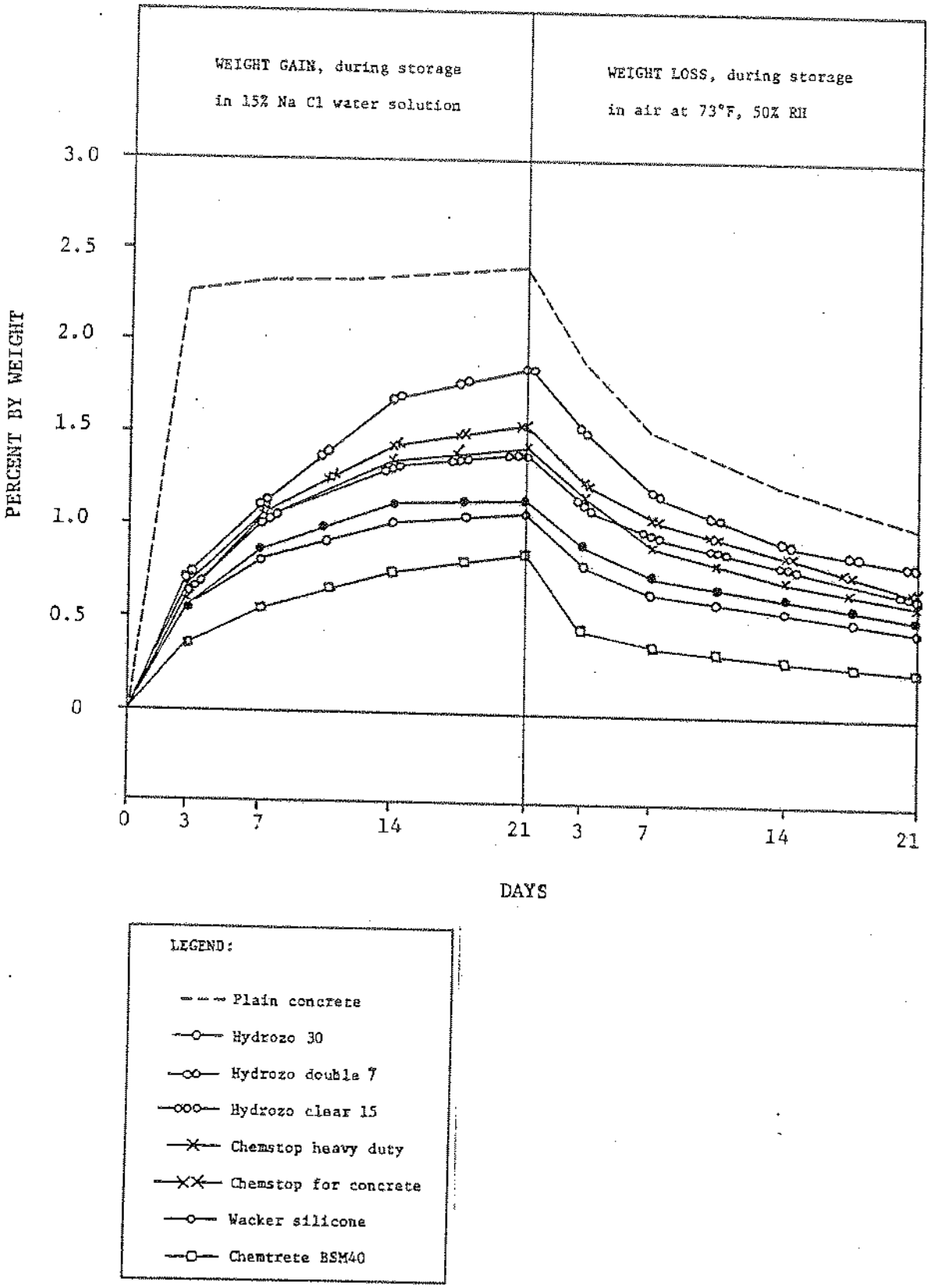

Fig. 5 - Weight gain and loss data

TABLE 2 - TOTAL CHLORIDE ION CONTENT IN CONCRETE

Name of Product	Chloride Ion Content (% by weight of concrete) Individual	AVG
Hydrozo Clear 30	0.022 0.087	0.055
Hydrozo Double 7	0.180 0.188	0.184
Hydrozo Clear 15	0.069 0.089	0.079
Chemstop Heavy Duty	0.027 0.126	0.077
Chemstop for Concrete	0.098 0.167	0.133
Wacker Silicone	0.047 0.176	0.112
Chemtrete BSM-40	0.034 0.058	0.046
Plain Concrete	0.225 0.244	0.235
Untested plain concrete control samples tested in air		<0.007

TABLE 3 - RELATIONSHIP BETWEEN WATER ABSORPTION AND ADJUSTED CHLORIDE ION CONTENT

Name of Product	Average Weight Gain During Soaking (% by wt)	Average Weight Loss During Drying	Average Weight Loss/ Weight Gain at End of Test (%)	Adjusted Chloride Ion Content (% by wt of concrete)	Calculated Percent Chloride Ion Solution Absorbed into Concrete
Hydrozo Clear 30	1.09	0.45	59	0.047	4.3
Hydrozo Double 7	1.89	0.81	57	0.177	9.4
Hydrozo Clear 15	1.41	0.65	54	0.072	5.1
Chemstop Heavy Duty	1.43	0.62	57	0.070	4.9
Chemstop for Concrete	1.57	0.66	58	0.127	8.1
Wacker Silicone	1.14	0.53	54	0.105	9.2
Chemtrete BSM-40	0.83	0.24	71	0.039	4.7
Plain Concrete	2.43	1.04	57	0.228	9.4

CONCLUSIONS

A laboratory study has been completed on seven sealers identifed as Hydrozo Clear 30, Hydrozo Clear Double 7, Hydrozo Clear 15, Chemstop Heavy Duty, Chemstop for Concrete, Wacker Silicone and Chemtrete BSM-40. The purpose of the study was to evaluate these sealants for their ability to minimize the ingress of chloride-laden water into concrete. Results of these studies lead to the following conclusions:

1. Large differences were found in some cases in the weight gain and loss and in the chloride ion content between the two cubes which represented one sample. This data would seem to indicate that some of the sealant materials are not uniform. Based on these test results, when sealants were carefully applied to the concrete cubes under laboratory conditions, we could suppose that the performance of the sealants under field conditions would be similar or possibly worse.

2. Three sealants were identified as Hydrozo products (i.e., Hydrozo Clear 30, Hydrozo Clear 15 and Hydrozo Clear Double 7). They reduced the average total weight gain by 55, 42 and 23 percent, respectively, when compared to the uncoated concrete specimens. During the 21-day soaking period in 15 percent NaCl solution, they absorbed 4.3, 5.1 and 9.4 percent of chloride, respectively. These results indicate that Hydrozo Clear 30 showed the best performance from the Hydrozo products (and the second

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best from the seven tested sealants), probably based on the highest content of solids (30 percent). However, it must be noted that the reduction of the total weight gain ranged from 38 to 72 percent and the chloride ion content in one cube was found to be 2.3 times higher than was found in the other cube.

3. Two sealants were identified as Chemstop materials (i.e., Chemstop Heavy Duty and Chemstop for Concrete). Concrete treated with these materials gained and loss similar amounts of water during the soaking and drying period. They reduced the average total weight gain by 42 and 36 percent, respectively, when compared to the uncoated concrete specimens. During the 21-day soaking period in 15 percent NaCl solution, they absorbed 4.9 and 8.1 percent of chloride, respectively. These results indicate that Chemstop Heavy Duty showed more chloride screening capabilities than Chemstop for concrete. Concrete treated with both sealants showed a wide range of variation in weight gain and chloride ion content.

4. The sealant material identified as Wacker Silicone reduced the average total weight gain by 53 percent when compared to the uncoated control specimens and absorbed 9.2 percent of chloride during the soaking period. The concrete coated with this material showed the widest range of variation in weight gain (0.56 and 1.72 percent) and chloride ion content (0.047 and 0.176 percent).

5. The sealant material identified as Chemtrete BSM-40 reduced the average total weight gain by 66 percent (with the range from 58 to 74 percent), when compared to the uncoated concrete specimens and absorbed the lowest amount of chloride ion after 21 days of soaking. These results indicate that the Chemtrete's BSM-40 material showed the best performance of the seven tested sealants.

Respectfully submitted,

WISS, JANNEY, ELSTNER AND ASSOCIATES, INC.

Dr. Stella L. Marusin

Dr. Stella L. Marusin
Project Manager

DYNAMIT NOBEL

TECHNICAL SERVICE REPORT

TO: Ruth Gregory

FROM: Jim Steinmetz

DATE: May 13, 1983

SUBJECT: Watts Towers Cubes

TESTS RUN: Standard Water Uptake

PRODUCTS TESTED: BSM - 40, 40 - H, 40 - V

Procedures and Results

Fifteen 2 inch cubes were received from Ward Treadwell along with the attached memo. The cubes were dried at 215°F overnight then allowed to come to ambient temperature and treated with the various BSM products by dipping (approximate dosage rate = 200 ft²/gal.). After a 5 day moist cure period the blocks were redried at 215°F and immersed in water for 24 hours. Weight gain due to water uptake was measured.

Block #	Treat	% water uptake	
A	None	7.86	7.0% average
B	None	6.55	
C	None	6.6	
D	BSM-40K	1.41	1.4%
E	BSM-40K	1.73	
F	BSM-40K	1.15	
G	BSM-40H	0.99	1.2%
H	BSM-40H	1.51	
I	BSM-40H	1.11	
J	BSM-40V	1.03	1.15%
K	BSM-40V	1.31	
L	BSM-40V	1.10	

JRS/ht

2. Epoxy Grouting System

No testing of epoxy grouting has yet taken place. There are two potential problems in use of epoxy grouting on the Towers.

1. The need to apply and later remove an adhesive seal or dam to the crack face to resist injection pressure. This seal is usually provided using a high modulus epoxy which must be chipped off subsequently with the risk of damage to adjacent ornament.

2. The risk of improper curing of the injected epoxy is unavoidable, whether due to human error or mechanical failure, and the process is irreversible. Normal practice in concrete repair using the technique is to take sample cores of injected areas to check that curing of the epoxy is complete, and that would be unacceptable at the Towers.

In our view no further discussion should take place on whether or not to use epoxy grout. The material would be useful on only one type of crack. That is a crack larger than a micro-crack or capillary that can be sealed by the polymerization of water repellant in adjacent pores, and smaller than the lower limit for use of a caulk. Furthermore the technique would be for use only where it was not planned eventually to reconstruct a member or intersection.

In view of our present recommendation to reconstruct deteriorated members that are vital to resisting horizontal loads, rather than re-adhering large fragments of original material, the number of cracks that could be sealed by epoxy grouting is significantly reduced. Given the difficulty and considerable expense of the technique it may be more prudent to use the most successful of the caulks (Dow 795) recently tested on the towers, even on cracks that are smaller than the minimum dimension recommended by the caulking manufacturer or where the recommended configuration of sealant cannot be achieved (e.g. a bandage caulk). Although not perfect, this approach would not be irreversible like epoxy, and caulk can be re-applied during periodic maintenance.

The decision not to pursue epoxy grouting need not be final. Should Adhesive Engineering or another come up with a formulation of suitably low modulus that can achieve deep penetration at low pressures and can be reliably mixed, then it should be tried on the towers. Our feeling though is that it is unlikely that such a material will be found in the near future.

C. RECOMMENDATIONS

These recommendations are largely as presented in February 1983 and subsequently reviewed and discussed by interested parties, whose comments have been addressed. However this material and that in the Maintenance Sections have been re-formatted as Repair and Maintenance Guide, bound separately, for use in the field.

1. Philosophy

Despite the large amounts of time and funds that have already been expended on the repair and restoration of Watts Towers, much work remains to be done. The tasks required for complete preservation of the Towers are outlined in the following sections, based on inspections and analysis described in Part I, Section II.B. Since funds are limited and required work extensive, the work items have been arranged in a general order of precedence, from most to least critical. Priorities were developed according to the philosophy outlined in Part I, Section II.A.: (1) life safety, (2) durability and (3) artistic integrity.

In most cases, required repair techniques will be the same as those currently in use at the site or as modified according to Part I recommendations. This includes careful inspection of each problem, determination of appropriate repair techniques and records keeping. Techniques selected will encompass cleaning or replacement of reinforcement, removal and reattachment of original mortar, patching with new mortar, crack-filling, etc. New repair tasks are described as required.

2. Schedule

a. Repair all armature deterioration and major cracks (½" wide and larger) in West, Center and East Towers.

b. Repair all armature deterioration and major cracks (½" wide and larger) in:

- Overhead Arches
- Gazebo
- Walls
- Small Towers # 1 and #2, Pinnacles and Ship.

c. Readhere all loose ornament on West, Center and East Towers.

d. Readhere all loose ornament on Overhead Arches, Gazebo, Walls, Small Towers # 1 and #2, Pinnacles and Ship.

e. Fill all cracks smaller than 1/2" in West, Center and East Towers.

f. Fill all cracks smaller than 1/2" in Overhead Arches, Gazebo, Walls, Small Towers #1 and #2, Pinnacles and Ship.

g. Cover all exposed surfaces with water repellant coating. If this cannot be done at one time, partial coating with Chemtrete BSM40 should be done with the limit of work clearly marked with permanent tags, removed only when work continues.

h. Stabilize ruins of House. This work should include the following elements:

--Clean and prime all exposed steel armature. Repair or replace armature as required.

--Stabilize exposed wood trim through use of clear preservative coating such as Chemstop Wood Waterproofing.

--Repair cracks and holes in masonry.

--Construct armature and backing for House elements (front wall, piers, chimney) sufficient to withstand anticipated lateral loads. Support may incorporate a new structure to serve as permanent facilities for Towers maintenance, interpretation, sales and other activities. This new structure should be designed according to the following guidelines:

. The new structure should be distinct from that of the remaining ruins, though supports may connect the original elements to the new structure.

. The new structure should not attempt to replicate original detail, though it may echo the shape of the original house (i.e., with a gable roof of the pitch shown in 1930's photographs).

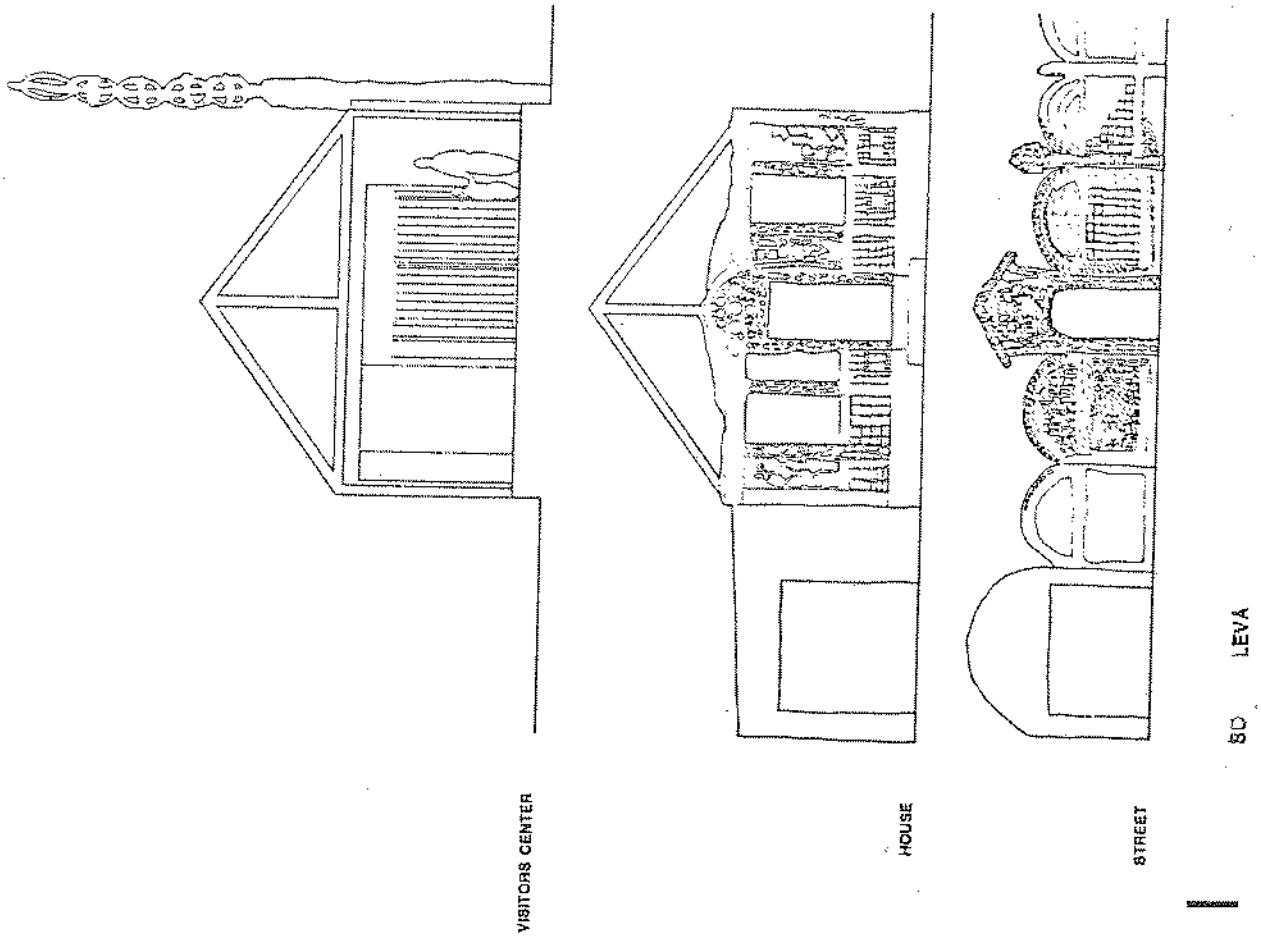
. Walls, openings, roofing and all other elements of the new structure should be as simple in design as possible, so as not to detract from the original sculpture.

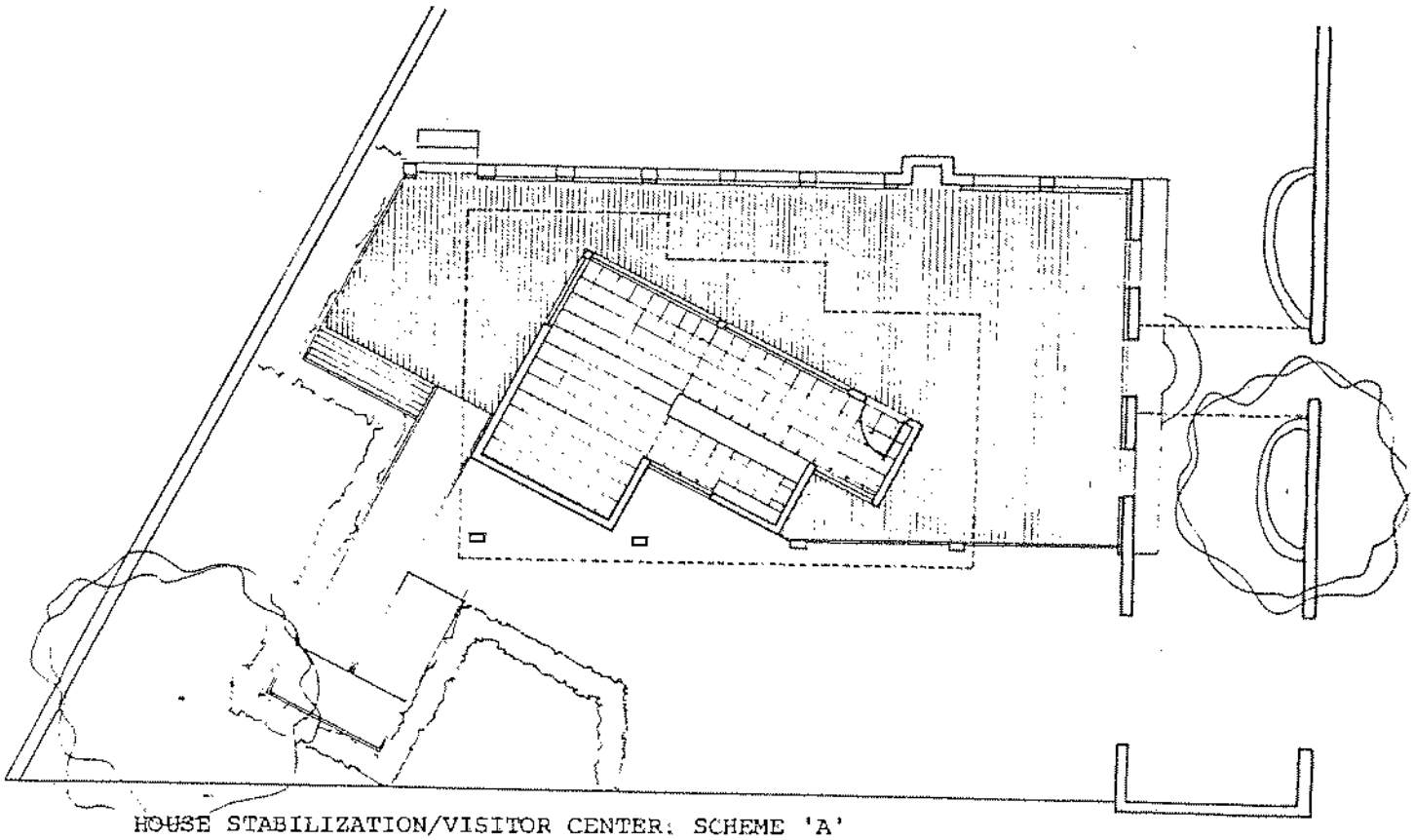
The schematic designs on the following pages illustrate two options for such a structure.

i. Replace gates in their original locations.

j. Provide fiber mats to protect flooring and steps exposed to visitor traffic.

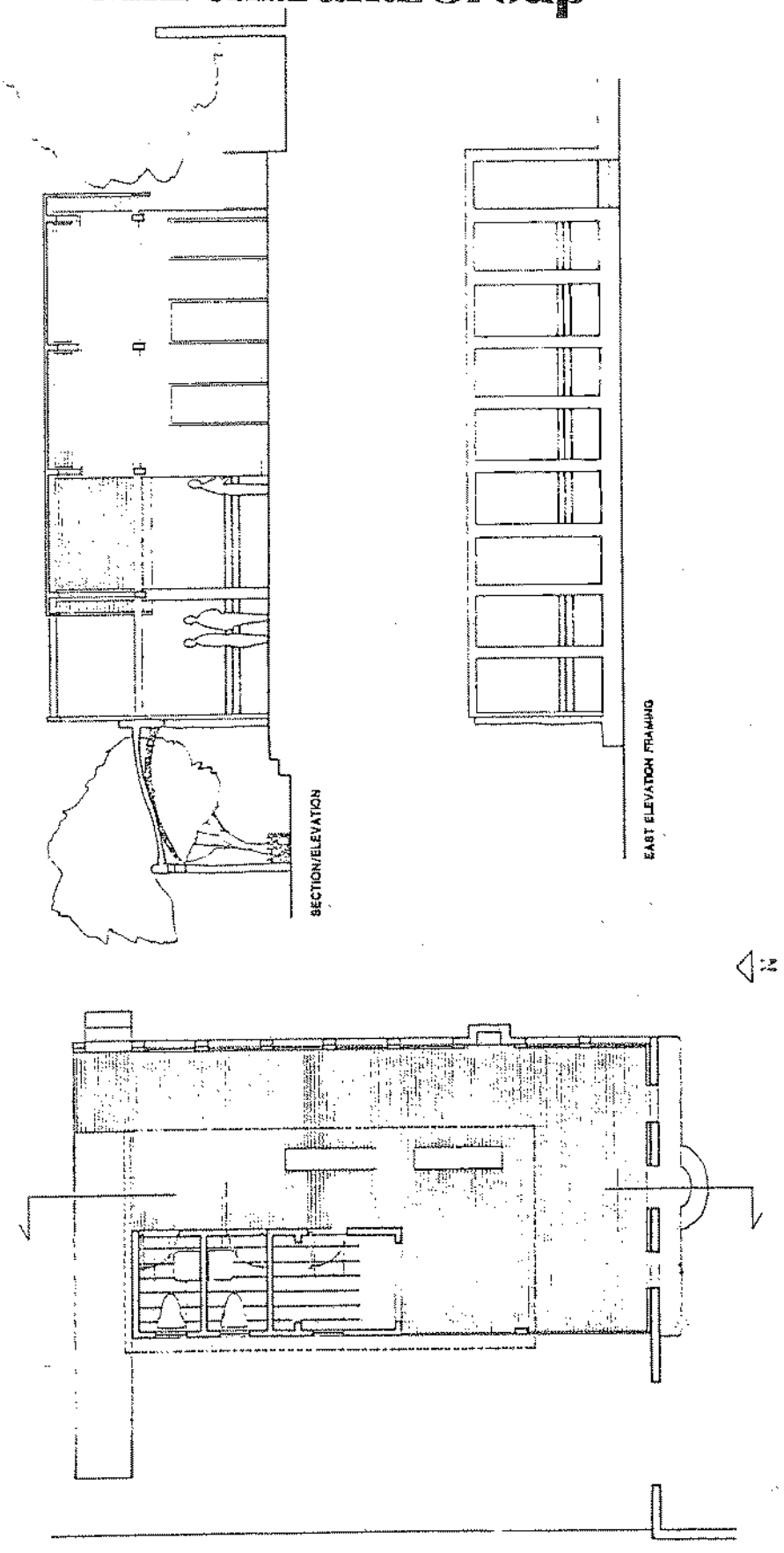
k. Label all ornament with identification numbers.





HOUSE STABILIZATION/VISITOR CENTER: SCHEME 'A'

TheEhrenkrantzGroup



HOUSE STABILIZATION/VISITOR CENTER: SCHEME 'B'

3. Specifications

These specifications do not cover all aspects of the work. They deal with materials, workmanship and procedures necessary to accomplish the two basic repair methods identified in the structural analysis (Part I, Section II.C). In this section the two techniques are first described in general terms, and conditions for their use are explained. Subsequently more detail is given for Inspection/Stabilization Mortar repair and replacement related to both repair methods, Water Repellent Application, and Paint Coating for Steel.

Structural Repair Methods. Structural repair techniques for the two categories of repair are generally described in this section. The end result of the repair technique and general procedures for obtaining the intended performance are described. The wide variation in original materials, degree of corrosion of the metallic core and physical relation of members will require a thorough understanding of the repair concepts by the restoration craftsman.

The repair technique that has a high priority for salvage and replacement of historic fabric is termed method A. The following procedures for method A repairs are recommended.

a. Remove the spalled historic fabric as intact as possible. Cut out the interior of the original mortar covering to leave an intact exterior fabric.

b. Remove the corroded metallic core if more than one-third of the original area has been lost to corrosion. Remove and salvage the original exterior mortar to expose two inches minimum of the original metallic core. Remove corrosion from the original core. Coat with anti-corrosion material.

c. Replace the original core with a stainless steel member equal to or exceeding the area of the originial core.

d. Lap the replacement core with the extensions of the original core. Wrap the splice with stainless wire.

e. Coat the metallic core with the specified bonding agent and wrap with stainless steel wire cloth previously cut to size.

f. Apply additional mortar to the coated core. Place the salvaged exterior pieces on the core. Allowance should be made for the pieces to be solidly driven into the mortar backing to assure full bedding. Allowance shall be made at joints of pieces to allow excess mortar backing to be extruded from the back of the applied piece.

g. Fill the joints between pieces with the specified mortar and cure the completed repair.

The repair technique for members in high stress and/or critical areas shall be termed method B. The following procedures for method B repairs are recommended.

a. Remove the spalled mortar after recording all information necessary for replication of the member.

b. Expose a minimum of four inches of the metallic core that has a minimum of 90% of the original cross section.

c. Replace the corroded section of the core with a member of equal or greater cross-section.

d. Wrap the splices with stainless wire. Apply the specified bonding agent to the core and wrap the splice with stainless steel wire cloth.

e. Build up the mortar coating to the original dimension. Apply ornamentation and original design to the completed repair. Additional specification of materials and procedures is given in Specifications for Maintenance and Repair.

The method B repair shall be utilized in the following described zones. Method A splices may be used in all other zones.

PERGOLA. Critical members are the nineteen radial dome ribs that meet at the apex. Use method B for the radial ribs from the center to outside the two bands adjacent to the center.

WEST TOWER. Critical members are the columns, bands and spokes in the lower thirty-five feet of the tower. (Below the top of the band of diagonal bracing.) Above elevation thirty-five feet, any repair in a column adjacent to a column with a previous repair or type A repair, and within two bands distance shall be spliced with type B method. Repairs in the adjacent two bands above or below a type A column splice shall be made by type B methods.

CENTER TOWER. This tower consists of three sub-towers, an inner, intermediate and exterior tower plus a center core. Critical members are columns, bands, and spokes in the lower thirty-five feet of height. Above elevation thirty-five, use same recommendations as for west tower, except all spokes shall be repaired by method B. Original splices of the columns using a pipe section for a core tend to have a minimal splice distance and tend to be more deterioratd than non-spliced zones. Original splices appear to be near each band in the lower thirty-five feet of the intermediate sub-tower and near band eight in the inner sub-tower. Repairs near these locations shall be extended to inspect the original splice. Method B repairs shall be made across the original splice if the original splice length is less than that recommended for method B.

EAST TOWER. This tower consists of two sub-towers, an inner and exterior plus a center core.

Critical members are inner columns and bands below the column cross-over at about elevation twenty feet, except for columns that do not extend to the base. Other critical members are exterior columns and bands from the base to elevation forty-five feet (at the level of the top arched brace to the center tower). All spokes are critical members.

The cores of all columns extending from the base are probably pipes and the recommendations for investigating the original splice as described for the center tower apply.

BRACES BETWEEN WALL AND ISOLATED TOWERS. These members are critical members and shall be repaired by type B methods.

INSPECTION/STABILIZATION

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK: Work shall include the inspection of unrepaired areas of the structure and the temporary securing of loose sections of mortar or imbedments. The intent is to secure the original fabric in its original location until permanent repair can be completed, thereby reducing the incidence of loss of original mortar and decorative embedments.

1.02 SCHEDULING: Temporary securing of loose mortar and imbedments should be conducted immediately, prior to proceeding with the repair work.

PART 2 - PRODUCTS

2.01 STRAPPING: Stainless steel or nylon, of the type used for securing shipping crates, which is fastened with a metal or nylon clamp, for example Band-it Co., Denver, CO 80216.

2.02 DUCT TAPE: Coated cloth, self adhesive tape.

2.03 WIRE MESH: Stainless steel or galvanized wire cloth/mesh with opening size 1/2 inch or less.

2.04 WIRE: Miscellaneous S.S. or galvanized wire.

2.05 CAULK: Dow Corning 795 Silicone Sealant.

PART 3 - EXECUTION

3.01 Wrap seriously cracked and loose mortar sections with strapping or wire mesh as appropriate to fragment size. Strapping or mesh should be tight enough to secure mortar in place but not place any pressure on the material.

3.02 Wrap loose embedments with duct tape or wire mesh, sufficient to bind securely in place.

3.03 Where mortar sections have not become completely detached and the repair will not be completed in the season during which inspection takes place, caulk all cracks using polyethylene foam backer rod where applicable.

MORTAR REPAIR AND REPLACEMENT

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. Work of this section includes but is not limited to the following:

1. Removal of damaged mortar covering.

2. Repair of damaged areas at critical structural members with new mortar.

3. Repair of damaged areas at non-critical structural members with new mortar in combination with resetting of original mortar fragments.

4. Repair and resetting of the decorative embedments.

B. Related Work Specified Elsewhere

1. Documentation

2. Steel repair and replacement

3. Water repellent coatings

1.02 DELIVERY, STORAGE AND HANDLING

A. Deliver material to the site, ready to use in the manufacturer's original, and unopened containers and packaging, bearing labels as to type of material, brand name, and manufacturer's name. Delivered materials shall be identical to approved samples.

B. Store materials under cover in a dry and clean location, off the ground. Remove materials which are damaged or otherwise not suitable for installation from the job site and replace with acceptable materials.

C. Protect aggregate and sand from contamination from dirt and other foreign materials. Store perishable materials in watertight structures, or covered with waterproof tarpaulins.

D. Accept, store and take delivery of all items, which are to be furnished by other Contracts and installed into the work of this Subdivision such as stainless steel reinforcement.

E. Note materials deliveries in Project Log and date stamp or mark containers and packaging.

1.03 JOB CONDITIONS

A. Do not mix or place mortar in rain or when temperature falls below 40 degrees F.

B. Protect adjacent original material during placing of mortar. Lay gound sheets over pavement beneath work to catch droppings.

C. Remove all materials to secured restoration work area at the end of each day's work.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Portland Cement: ASTM C150, Type I.

B. Pigmented Cement: ASTM C150, Type I, portland cement pre-mixed with insoluable, inorganic, light stable pigments and containing no other additives, such as Riverton Corporation's "Flamingo Colorport".

C. Lime: ASTM C207, hydrated mason's lime, Type S

D. Aggregate: Clean sharp natural sand conforming to the following size gradations and the requirements of ASTM C144.

Sieve Size	Percentage Passing
No. 4	100
No. 8	95 - 100
No. 16	70 - 100
No. 30	40 - 75
No. 50	20 - 35
No. 100	2 - 15
No. 200	0 - 2

1. The color of the sand may affect the final mortar color. Choose sand which results in a mortar mix which most closely matches the existing general aggregate color.

E. Water: Potable, free of oils, acids, alkalies and organic matter.

F. Admixtures: Use no admixtures other than 10% maximum of mix water may be Acryl 60 as manufactured by Thoro System Products, Newark, CA.

G. Bonding agent/adhesive: High-modulus, high strength, moisture insensitive epoxy adhesive; Sikadur Hi-Mod Sikastix 370 as manufactured by Sika Chemical Corporation, Lyndhurst, NJ 07071. Acryl 60 for bonding fragments in type A repairs.

H. Glass adhesive: Opticon UV

2.02 MIX PROPORTIONS

A. Repair and replacement mortar.

1. Cement: 1 part by volume.

2. Lime: 1/10 to 1/4 part by volume.

3. Sand: 3 parts by volume dry.

4. Water: minimum to form a workable mix. Acryl 60 must be diluted prior to adding to dry mix.

2.03 MIXING PROCEDURES

A. Match the mortar color to the original existing mortar.

B. Measure materials by volume or equivalent weight. Do not measure by shovel, use known measure. Record measures used in Project Log.

C. Mix mortar using a clean mechanical batcher. Mix dry ingredients for one minute prior to the addition of water. Thoroughly mix for three minutes after the addition of the water.

D. Place mortar within two hours of mixing. Do not retemper or use partially hardened material.

PART 3 - EXECUTION

3.01 EXISTING MORTAR REMOVAL

A. Fully document the location and placement of the mortar fragments and embedments prior to removal.

B. Carefully pry loose the damaged mortar. Tag and store all fragments and embedments for future use.

3.02 STEEL PREPARATION: Repair and prepare the steel surfaces as per Method A or B and "Paint Coating for Steel."

3.03 REPAIR AT CRITICAL STRUCTURAL MEMBERS - METHOD B

A. Cut back the edges of adjacent existing mortar in preparation for new mortar application. Cut edges as square as possible, with a slight bevel inward to provide a key for the new mortar.

B. Thoroughly coat all exposed steel and adjacent bond edges of the existing mortar with the Sikadur Hi-Mod bonding agent. Do not apply bonding agent to surfaces which will remain exposed at the completion of the repair.

C. Hand pack the mortar onto and into the steel, mesh, wire, etc. Tightly pack and compress the mortar to fill all voids and achieve completed coverage of all metal surfaces. Fill and pack tightly any hollow metal sections.

D. Build out the initial mortar layer to the surface of the steel. Allow mortar to become thumb print hard prior to applying subsequent layers. Roughen the surface of the mortar to provide a key for the next layer.

E. Apply suceeding mortar layers in maximum one inch thich increments.

F. Continue applying mortar layers until the profile of the repair area matches the original profile or until the minimum mortar cover of the steel members reaches one inch, whichever is greater.

G. Once the original profile or minimum cover is reached, reset the embedments while the mortar is still plastic. Locate embedments at their original locations and depth.

H. Set the embedments by rocking and tapping into place to insure complete contact with the mortar bed.

I. Finish the surface of the new mortar to match the texture of the original fragments removed from the repair area.

J. Keep mortar damp by wrapping and/or misting for no less than 48 hours to prevent too rapid drying. Extend the time period until mortar is fully cured depending upon temperature and relative humidity.

3.04 REPAIR AT NON-CRITICAL SRUCTURAL MEMBERS - METHOD A

A. Cut back the edges of the adjacent, exisitng mortar in preparation for new mortar application. Cut edges as square as possible with a slight bevel inward for key.

B. Prepare the original mortar fragments for resetting in the new mortar base.

1. Cut the edges of the fragments square with a slight inward bevel.

2. Trim the edges as required to create a minimum 3/8 inch joint between the mortar fragments when they are reset. In no case shall there be a fragment to fragment joint/bond.

3. Cut out the back surface of the fragment. The amount of material to be removed will depend upon the condition of the fragment, depth of embedment penetration, and the overall thickness of the member section. Use the following guidelines.

a.Minimum thickness of mortar remaining at the point of the deepest embedment penetration shall be 3/4 inch.

b.Minimum new mortar coverage of the steel exclusive of the fragment thickness shall be one inch.

4. Leave the back of the fragment rough to provide key.

5. Clean the back and edges of the fragment to remove all loose material, dirt, oil, etc. Use no chemicals.

C. Thoroughly coat all exposed steel and adjacent bond edges of existing mortar with Sikadur Hi-Mod. Do not apply bonding agent to surface which will remain exposed when the repair is completed.

D. Hand pack the mortar onto and into the steel, mesh, and wire. Tightly pack and compress the mortar to fill all voids and achieve complete coverage at all metal surfaces. Fill any hollow steel sections fully with mortar and pack tightly.

E. Build out initial mortar layer to the surface of the steel. Allow mortar to become thumb print hard prior to applying subsequent layers. Roughen surface to provide key.

F. Apply suceeding mortar layers in maximum one inch thich increments.

G. Continue applying mortar until the minimum coverage of the steel members with new mortar reaches one inch or until the profile with the mortar fragments reset will match the original, whichever is greater.

H. While the mortar is still plastic, set the mortar fragments.

1. Apply Acryl 60 cement slurry to the back and edges of the fragment.

2. Set fragment by rocking and tapping in place to insure complete contact with the mortar. Maintain the one inch new mortar coverage of the steel.

3. Fill joints between the fragments with mortar, pack tightly and toll to compress the surface mortar.

I. Once fragments are set finish the surface of the new mortar to match the texture of the fragments.

J. Keep mortar damp by wrapping and/or misting for no less than 48 hours to prevent rapid drying. Extend time until mortar is fully cured depending on temperature and relative humidity.

3.05 REPAIR AND RESETTING OF EMBEDMENTS

A. Set all available embedments in their original locations as documented prior to removal.

B. Do not repair broken embedments prior to resetting except as necessary for ease of handling.

1. If repair prior to setting is required, join pieces with a good quality, fast setting, exterior grade epoxy adhesive. Remove all adhesive from exposed surfaces of the embedments using the manufacturers recommended solvent.

C. Clean all surfaces of the embedments to remove dirt, oil, and other foreign matter, using water and a mild detergent such as Joy dishwashing soap.

D. Resetting Embedments in New Mortar

1. Soak unglazed, porous embedments in clean water for 30 minutes minimum to reduce suction.

2. While repair mortar is still plastic, set embedments by rocking and tapping in place. Press embedments into the mortar to ensure complete contact with the mortar at the back surface and all edges.

3. Where embedments are in several pieces, set each piece separately, creating a small 1/16th inch mortar joint between pieces.

4. Maintain the one inch minimum mortar cover of the steel members when setting the embedments in members repaired using Method B (critical members). Maintain minimum 1/2" cover to steel when Method A repair is used.

E. Resetting Embedments onto Mortar Fragment.

1. Clean all of the mortar fragment to receive the embedment. Remove all loose material, dirt, oil, etc.

2. Roughen the surface of the mortar fragment to provide key.

3. Soak unglazed, porous embedments in clean water for 30 minutes minimum.

4. Apply Acryl 60 cement slurry to the mortar fragment area to receive the embedment. Do not allow bonding agent to coat any exposed fragment surface.

5. Apply mortar to fragment and set embedment into mortar by rocking and tapping in place. Press embedment firmly into mortar to ensure complete contact at back and edges.

6. Maintain minimum 1/8 inch mortar thickness between back of embedment and mortar fragment.

7. In the case of clean single embedments that have lost adhesion, without consequential loss of mortar matrix, re-adhere to mortar fragment using Dow Corning 795 Silicone building sealant.

WATER REPELLENT COATING

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK:

A. Work shall include preparation of surfaces and application of water repellent coating.

B. Related Work:

1.02 SCHEDULING:

A. Water repellent coating shall be applied after completion of repairs.

1.03 DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the job site in the approved manufacturer's original containers and packaging clearly labeled. Delivered material shall be identical to approved material used in lab test.

B. Store and mix water-repellent in strict accordance with manufacturer's instructions.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Water Repellent Coating: Trocal Chemtrete BSM-40R, obtainable from Curry/Rand, 600 16th St., Oakland, CA 94612.

PART 3 - EXECUTION

3.01 SURFACE PREPARATION

A. Clean surface of all loose material, grease, oil, etc.

B. Surface may be damp or dry but free of standing water and dry enough to see application pattern.

3.02 APPLICATION

A. Apply to repair areas only after repairs are completed and mortar has fully cured.

B. Apply using a low pressure (15 psi maximum) airless, hand pump sprayer, equipped with a fan type spray nozzle. All equipment must be completely free of water prior to use.

C. Saturate the surfaces, working from the bottom up. Apply to surface until coating is no longer absorbed and runs 6-8 inches below the spray pattern.

3.03 CLEAN-UP

A. Thoroughly wash all equipment and clothing after application using water.

B. If only part of a structure has been coated, permanently tag or otherwise indicate extent of application, for future continuation.

PAINT COATING FOR STEEL

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK:

A. Work of this section includes but is not limited to the following:

1. Surface preparation of existing steel.

2. Application of cold applied galvanizing compound to existing steel members.

B. Related Work Specified Elsewhere

1. Steel repair.

1.02 DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the job site in the approved manufacturer's original containers and packaging, bearing original labels with brand, type and color of paint clearly visible. Delivered material shall be identical to approved literature and samples submitted.

B. Store paint, varnish, enamel, oil, turpentine and other combustible or inflammable materials within the building in receptacles with tight covers. Remove oily or paint saturated cloths, rags, or waste from the building after each day's work or as directed.

1.03 JOB CONDITIONS

A. Maintain an ambient temperature of not less than 50 degrees F in all spaces or locations, where this work is in progress.

B. Exterior painting shall not be done in wet weather nor work in general performed during periods of high humidity which would prevent the attainment of satisfactory results.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Cold Applied Galvanizing Compound: Organic zinc rich primer, epoxy resin vehicle with minimum 50% zinc solids content such as ZRC Cold Galvanizing Compound.

B. Solvents: As recommended by manufacturer.

PART 3 - EXECUTION

3.01 SURFACE PREPARATION

A. Sandblast the steel to remove all scale, old paint, laitance, oil, grease, etc.

B. White metal blast-clean, NACE No. 1 is preferred; near white SSPC-SP-10 or Commercial Blast Cleaning SSPC-SP-6 are acceptable.

C. Preparation of the surface is critical to the successful performance of the coating and therefore must be thorough.

D. Prepare only the area of metal which can be coated within three hours of preparation. Metal standing longer than 3 hours without priming must be recleaned.

E. Remove blasting debris prior to coating with compressed air.

3.02 COATING APPLICATION

A. Apply coating within three hours after surface preparation. If scale begins to form on the surface of the steel, it must be re-cleaned.

B. Brush apply two wet coats of primer, minimum dry film thickness for each coat of 1.5 mils with total dft of 3.0 mils minimum.

C. Follow manufacturer's recommendations for drying/recoat times.

V. MAINTENANCE

V. MAINTENANCE

A. PHILOSOPHY

Maintenance of Watts Towers is a permanent battle against corrosion and the deterioration of the monument's mortar fabric. The present emergency stabilization effort should be seen as a period of "catching up" to offset long accumulated deterioration. The great value of the present work at the Towers is that it has cleared the air about appropriate techniques of repair, and has established a palette of workable materials and methods which allow an appropriate compromise between the aims of museum-quality restoration and the need for structural repair. Three things are necessary to keep the preservation effort on course:

1. No departures from materials and workmanship standards established without thorough research, testing and analysis. In particular use of novel materials should be guarded against. Our recommendations have been somewhat conservative but on a structure as brittle as Watts Towers it is prudent to avoid commitment to materials or procedures that are irreversible. For example, the use of caulking material should not be seen as permanent repair, but only as a temporary measure to prevent water ingress to the armature until a full mortar repair can be achieved in a future maintenance cycle.

2. Quality control of materials and workmanship. This is relatively straightforward as long as it remains under Ward Treadwell's experienced control, but may be more difficult later.

3. Documentation in the form of a maintenance handbook is the best weapon in quality control and the following of specifications. For example, in relation to the bagged mortars, orders would be logged in and only quantities needed for current work would be ordered. Supplies certificates would be kept.

The construction of the Towers is such that no repair program, short of total reconstruction or total enclosure, can ensure that deterioration will not continue. Therefore, any maintenance program for the site must take into account the need for recurring repairs of the type presently underway, as well as routine housekeeping. These repairs must be carried out with the same high standards of craftsmanship and conservatorial care as has been present in the past four years or all those efforts will have been wasted.

B. MAINTENANCE PROGRAM

1. Tasks

The maintenance program for the Watts Towers should include the following elements:

a. Housekeeping on a daily or weekly basis, depending on need as generated by amount of visitor traffic, etc. Primary tasks will include removal of dirt, leaves and litter from the site. Frequency, specific requirements and additional tasks will become apparent when the exhibition and tour program has been established. As part of the housekeeping program, fiber mats or another form of protection should be provided for decorative tile and concrete flooring which is under the tour route.

Housekeeping personnel should be oriented to the site and understand that all parts of the Towers--walls, floors, benches--are considered part of the art work. Tasks should be developed accordingly, using a minimum of water and no chemicals.

b. Inspection and Repairs need to be a regular scheduled feature of the maintenance plan, except for emergency inspections (see c. below). Because of the dynamic nature of the Towers' deterioration it can be assumed that all inspection will result in the need for work to be done. We suggest a three-to-five year cycle for inspection and repair work. Under this system, a different portion of the site would be scaffolded, inspected and repaired in turn each year. For example, the first year, the East and Center Towers would be treated; the second year, the West Tower and Gazebo; the third year, the walls, House, Small Towers and Ship.

The actual sequence would depend on where the emergency stabilization has reached. In our view it is unlikely that funds will be available to sustain a rate of repair work that will justify keeping all three main towers scaffolded. That has been extremely useful in establishing causes of deterioration, and in providing the facility to compare Rodia's work (and also problems) on the 3 towers. In future, though, it will be important for at least one of the towers to be generally visible to the public, if not accessible. In the first year, provided major work on the Center Tower can be completed under the present program, it may be that the West Tower should remain in scaffold. This approach would require some redesign of the scaffold so that enclosure of one tower could be stable. Scaffolds for the Gazebo and other inaccessible parts known to be in need of work could be made from the balance of the material. Based on scaffold re-design, guying anchors should be permanently established in the ground to receive cable shackles in the future.

Thus in a given year of the proposed cycle procedures would be more or less as follows:

1. Inspect previous year's work for any rapid deterioration from scaffold left in place (e.g. on West Tower).

2. Rent cherry-picker or use L.A. City machine to inspect other parts of towers using binoculars, and comparing findings with repair log of previous work.

3. Complete any work necessary from scaffold already in place.

4. Dismantle scaffold and erect new scaffold as determined by priorities from inspection.

5. Perform work from new scaffold.

6. Review housekeeping to ensure that procedures are not harming the historic fabric.

In general terms, it would not be advisable to do work to the Towers themselves while work is being done to lower features except where there is adequate distance (i.e., Ship and West Tower OK, Gazebo and West Tower, not OK). The schedule should basically follow that set out in Part II.C.2, except of course if funds are available work on the house and on ornamental fence should proceed. The sooner visitors can be accommodated the earlier contributions can be attached to help finance ongoing preservation work.

Repair techniques used in maintenance should conform to the specifications in this document, which should be repeated in the Maintenance Handbook for use on site. Repairs completed in maintenance should be photographed "before" and "after," so that any deterioration of repaired areas can be logged during inspection.

c. Emergency Inspections should be made following reports from curatorial, security or maintenance staff of vandalism, storm or earthquake damage or sudden, critical deterioration.

2. Personnel

As experience has already demonstrated, the critical element in the success of the maintenance program for the Towers will be the personnel selected to execute it. Since the City of Los Angeles is currently designated to be responsible for future maintenance, Rodney Punt of the Los Angeles Department of Cultural Affairs and Don Gambel of the Department of General Services were interviewed to determine the capability of their departments.

The Office of Cultural Affairs has no maintenance responsibility. They expect to provide a gallery attendent and security staff to the site once it is open to the public. They have recently lost the staff architect supervising activities at the Towers, and do not expect to receive a replacement. They anticipate charging an admission fee, which could be deposited directly into a maintenance account.

The Department of General Services maintained the Towers before they were taken over by the State. They currently are responsible for 800 buildings in the city, despite a 50% cutback in staff. They would be able to provide a "plasterer" to carry out repair work on the Towers, but could not guarantee that the same worker would be assigned to the task from year-to-year. There is also little assurance that adequate orientation, education and supervision of the required repair tasks would be furnished. The department's record-keeping system consists primarily of work tickets and work orders, which are kept for three years only.

There are two distinct categories of maintenance work to be carried out at the Towers: housekeeping and repair or restoration. Housekeeping tasks can probably be carried out by the Office of General Services; both Punt and Gambel expressed doubts that the City staff would have skills and attitude required to maintain the standards set by O.S.A. staff. With them, we recommend that yearly inspection and repair be contracted by the City of Los Angeles to the Office of State Architect.

3. Maintenance Handbook

Housekeeping, inspection and repair work should all be fully described in a Maintenance Handbook, with copies to be held by all organizations responsible for administering the work. The Handbook should include the following:

a. Historical summary of the structure and its significance.

b. Description of previous restoration efforts, including philosophy, locations, materials and techniques.

c. Description of inspection procedures, including symptoms of anticipated materials failure and recommended treatments therefor.

d. Repair forms and instructions for maintaining the record-keeping system presently used by OSA.

e. Listing of materials and suppliers.

f. Specifications for all maintenance work.

g. Drawings and photographs illustrating typical conditions and repair procedures.

4. Protective Measures

The development of policies and procedures regarding both life safety and security is necessary. Those organizations responsible for programs at the Towers should be involved in the operating policies established. Both the Office of Cultural Affairs, who expect to provide gallery and security staff, and the Committee for Simon Rodia's Towers should be included.

The primary consideration for life safety issues is to restrict exposure to hazards, while still providing an opportunity to view and appreciate the Towers.

To ensure the safety of persons at the Towers, both visitors and staff, the following measures should be considered:

a. Hours of Entry - Establishing set hours of operation and limiting visiting time within the walls is advisable.

b. Limiting Group Size - Limits on the size of groups and number of people within the walls would help reduce risk by keeping groups at a supervisable level.

c. Posted Notices - The City of Los Angeles should consider posting notices warning visitors that movement within the walls represents a voluntary hazard which the visitor is responsible for taking.

d. Hard Hats - All visitors should be issued hardhats when within the premises.

e. Release of Liability - All persons entering the premises of the Towers should be required to sign a legally approved statement releasing the City of Los Angeles from liability.

f. Docent Briefing - Docents should be briefed about safety measures and a telephone number should be provided with a legally appropriate message.

g. Banding All Loose Material - In the event tours are conducted during repair work, all loose material or members should be banded.

h. Close the Towers - During bad weather, such as heavy rain or high winds, the Towers should be closed, as otherwise there is an increased opportunity for injury.

i. Repair Clean-up - A conscientious repair program that does not leave significant amount of loose or deteriorated material in place longer than necessary should be instituted.

j. New Fencing - Serious consideration should be given to new fencing for the site, planned in conjunction with modifications to the end of E 107th Street. We share the view of John Outterbridge, Director of the Watts Towers Community Arts Center, that the fence should inhibit rather than prohibit, and should secure the Towers rather than provoke access. Local people in general care about the Towers and the fence should reinforce the sense of concern, not suggest a lack of concern about the Towers' setting. Chain link may be adequate during emergency stabilization, but would be inappropriate for permanent display.

Because the Towers are likely to remain inaccessible to visitors for some time to come, the fence should incorporate display boards

with information on the Towers and restoration work.

k. Lighting - Serious consideration should be given to installation of night lighting at the Towers, primarily in the interest of security. Any lighting design should be developed in consultation with nearby residents to ensure that siting is acceptable.

5. Neighborhood Relations

Community support is extremely important and necessary for the future success of the Towers. This is true in terms of both potential problems as well as opportunities.

Problems in this context relate to security of the Towers and the privacy of residents. It is important that the City of Los Angeles consult with community representatives about issues relating to fencing, lighting, parking, visiting schedules, and the future maintenance program. The community needs to feel the City cares about Watts Towers, and that consideration is being given to resident's concerns, particularly since CSRTW wishes to maintain and improve the generally good relations so far established.

This raises the question of opportunities for community support and involvement. In this context the Watts Towers Arts Center can play an important part, as suggested by John Outterbridge at a meeting in the Center on October 5, 1982. One idea is to achieve "block security" in which neighbors are keeping watch on the Towers; they would be briefed and would have a telephone number to call in the event of vandalism. Incentives in the form of rewards for information would be helpful. A related concept is to harness the energy of local gangs by inviting their participation in protecting the Towers, providing security at functions, etc.

In addition to security issues there are the more positive needs of collecting donations that visitors may wish to make towards the Towers upkeep, and in developing a docent system from within the community.

We strongly urge that, as the time approaches when the Towers will be more visible (if not more accessible right away) and visiting increases, the CSRTW should get together with the Watts Towers Arts Center staff and the City to review all these matters and from such a review to develop a management plan with three principal goals:

1. To achieve good security and protection of the Towers.

2. To satisfy the concerns of the block and the community.

3. To make the experience of visiting the Towers aesthetically memorable and informative.