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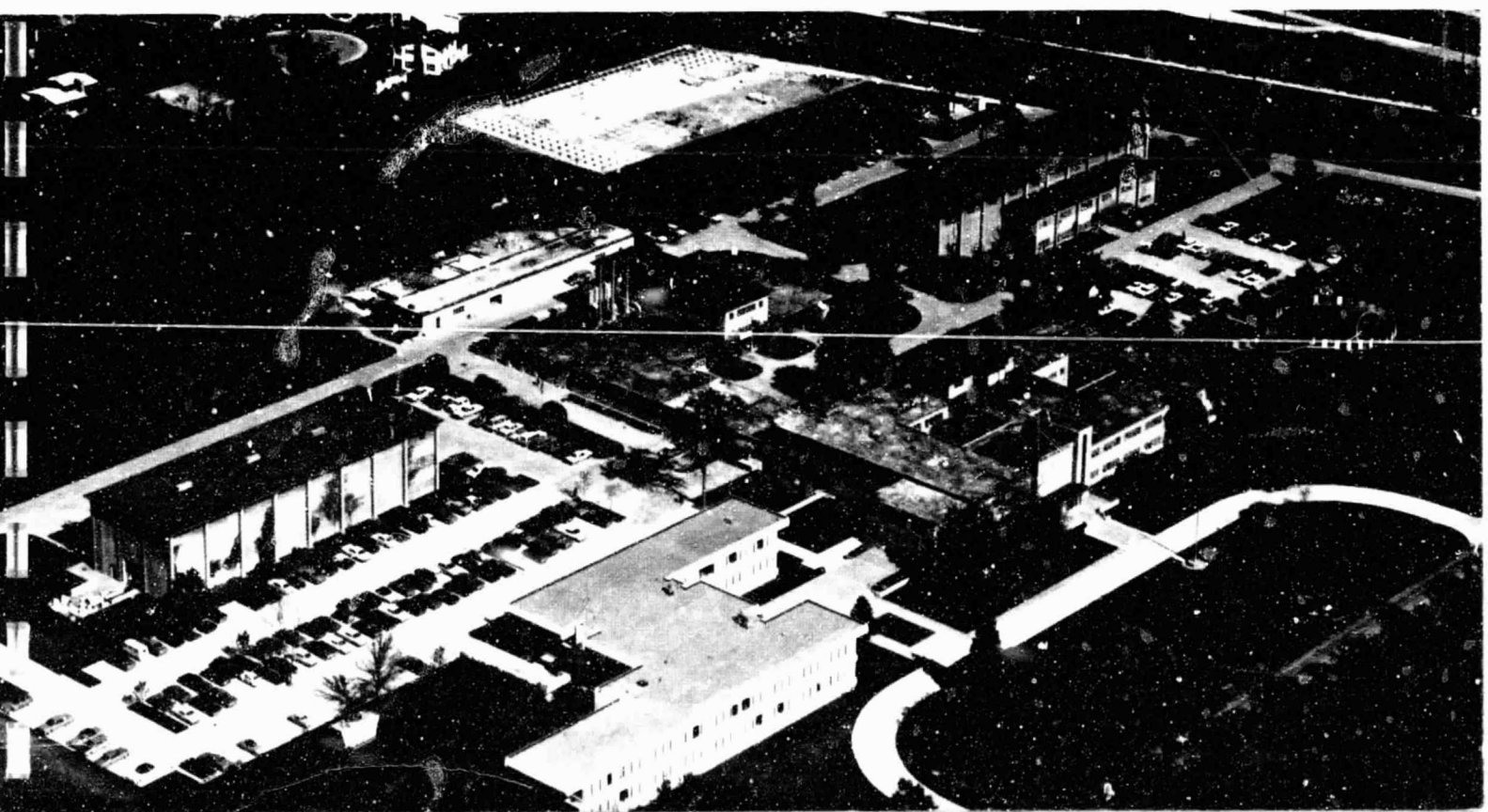


(NASA-CR-172074) EVALUATION OF DSS-14
 PEDESTAL-REVIEW OF TOP SURFACE REPAIR
 PROCEDURES (Construction Technology Labs.)
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Report To
JET PROPULSION LABORATORY
California Institute of Technology
Pasadena, California
JPL Contract No. 956493

EVALUATION OF DSS-14
PEDESTAL-REVIEW OF TOP SURFACE
REPAIR PROCEDURES

by

R. G. Oesterle
D. W. Musser
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Submitted by

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May 1983

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EVALUATION OF DSS-14 PEDESTAL-REVIEW
OF TOP SURFACE REPAIR PROCEDURES

by

R. G. Oesterle, D. W. Musser, and E. A. B. Salse*

HIGHLIGHTS

This report presents results of Construction Technology Laboratories' (CTL) review of proposed repair procedures for the top surface of the pedestal supporting the hydrostatic bearing runner for the 64m Antenna at DSS-14, Goldstone. Proposed repair procedures were prepared by Jet Propulsion Laboratory (JPL).

These procedures included:

1. Removal of existing grout and concrete to approximately 8 in. below original concrete surface using a presplitting technique with expansive cement followed by secondary breaking.
2. Preparation of exposed concrete surface including an epoxy bonding agent.
3. Replacement of material removed with 8 in. of new concrete and 4 in. of new grout.

The procedures were submitted to CTL for evaluation and recommendation of alternate techniques or materials, if necessary. Procedures were reviewed by CTL and comments and recommendations

*Respectively, Manager, Analytical Design Section; Director, Construction Methods Department; and Director, Structural Evaluation and Fire Research Department, Construction Technology Laboratories, a Division of the Portland Cement Association, Skokie, Illinois.

were transmitted to JPL during a series of the phone conferences. This report confirms these telephone conferences.

Following the telephone conferences, JPL requested specifications for concrete replacement procedures, concrete mix design, and creep properties of an epoxy grout being considered for use. Specifications and preliminary mix design are included in the Appendix of this report. Mix design will be finalized when 28 day characteristics are available at the end of May 1983. Creep tests of epoxy grout are in progress. Results will also be reported at the end of May 1983.

Evidence of alkali-silica reaction has been found in the pedestal concrete. It is possible that expansion of reaction product is a global problem for the structure. If so, repairs significantly beyond the scope of procedures discussed in this report may be required. Comments and recommendations in this report concern procedures for repair in the local region under the hydrostatic bearing runner. The alkali-silica reaction problem is being investigated by CTL under a separate contract. Possible rehabilitation programs for the global problem will be included in a separate report.

Based on CTL's review, the following comments and recommendations are presented:

- (1) Concerning depth of removal, it is only necessary to remove existing concrete to sound material. However, CTL agrees that specifying removal of concrete to a consistent depth is advantageous for control of construction.

- (2) Staff of JPL indicated that a depth of approximately 8 in. is required to remove concrete to a level of 2 in. below the layer of existing reinforcement in top of the haunch region. Photographs of reinforcement taken during original construction indicates that a depth of approximately 10 in. is required.
- (3) Presplitting and secondary breaking is a good technique for concrete removal. Of the two methods of presplitting available, hydraulic splitters or expansive cements, presplitting with an expansive agent is the more feasible technique for this application. However, because the material will be used in horizontal holes and in a desert environment at high temperatures, it is recommended that trial use of expansive cement be conducted on a mock-up of the haunch area concrete.
- (4) It is recommended that the outside vertical surface of the haunch be "scribed" with a horizontal sawcut to control the presplitting crack. Also, it is recommended that the boreholes be lined with a thin flexible sleeve to prevent seepage of the expansive agent slurry into existing large cracks in the haunch concrete.
- (5) If large oil saturated surfaces are found after concrete removal, the surfaces should be cleaned prior to placing new material. Procedures are contained in specifications in the Appendix of this report.
- (6) Use of a Portland Cement grout is recommended as a bonding agent. A Portland Cement grout will perform

as well as an epoxy for bonding new concrete to the old surface and will be less expensive.

- (7) The existing top layer of circumferential reinforcement is No. 8's at 12 in. on-center placed with approximately 5 in. of cover. It is recommended that, for better crack control of new concrete, a new layer consisting of larger number of smaller diameter bars be added. Thirteen No. 5 bars placed with a 2 in. concrete cover and evenly distributed across the width of the new concrete will be effective for crack control.
- (8) Creep characteristics of the epoxy grout should be evaluated. Creep tests are currently being conducted by CTL. Results will be reported at the end of May 1983.
- (9) Specifications and trial mix design for new concrete are included in the Appendix of this report.

INTRODUCTION

At the request of Mr. H. P. Phillips of the Jet Propulsion Laboratory (JPL) and as authorized by JPL Contract No. 956493, an evaluation was made of proposed repair procedures for the top surface of the pedestal supporting the hydrostatic bearing runner for the 64m Antenna at DSS-14, Goldstone. A photograph of the antenna is shown in Fig. 1. This report presents results of Construction Technology Laboratories' (CTL) evaluation.

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Figure 1. 64m Antenna at DSS-14, Goldstone

Background

The supporting structure for the C4m Antenna is a cylindrical reinforced concrete pedestal consisting of spread footing, wall, haunch area, top slab and collar as illustrated in Fig. 2. Construction of the pedestal was completed in 1964. The antenna has been in operation since 1966.

Vertical loads from the antenna are supported by three hydrostatic bearings riding on the top of the haunch area. Lateral loads from the antenna are supported by roller bearing thrust assemblies riding against the collar. The three hydrostatic bearings are located at equal distances around the perimeter of the pedestal. An enlarged cross section through the hydrostatic bearing system is shown in Fig. 3. The alidade transmits vertical load through a ball socket to the bearing pad. This bearing pad is approximately 60 in. long, 40 in. wide and 20 in. thick. This pad rides on a thin film of pressurized oil on top of a 5-in. thick steel runner. The runner plate rests on sole plates set in grout on top of the haunch area concrete.

Proper operation of the hydrostatic bearing requires extremely small tolerances in oil film thickness. Therefore, the runner plate must be set in a very "flat" position. The design permitted a maximum "out-of-flatness" of 0.003 in. over a pad length of 60 in. Maintaining "flatness" of the runner has been a continuing problem almost from the beginning of operation of the antenna. A special non-shrink grout used in the initial installation of the runner apparently promoted corrosion of the

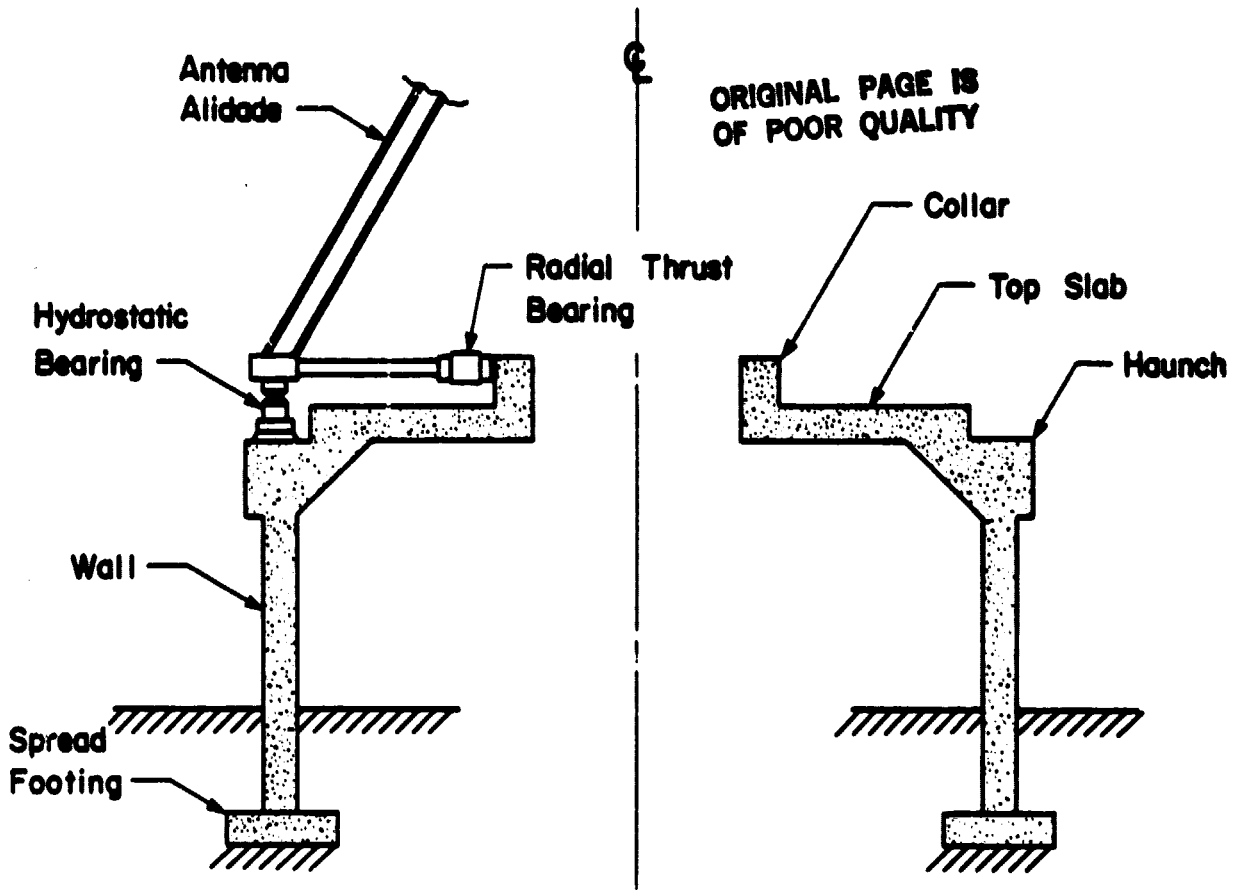


Fig. 2 Cross Section of Concrete Pedestal

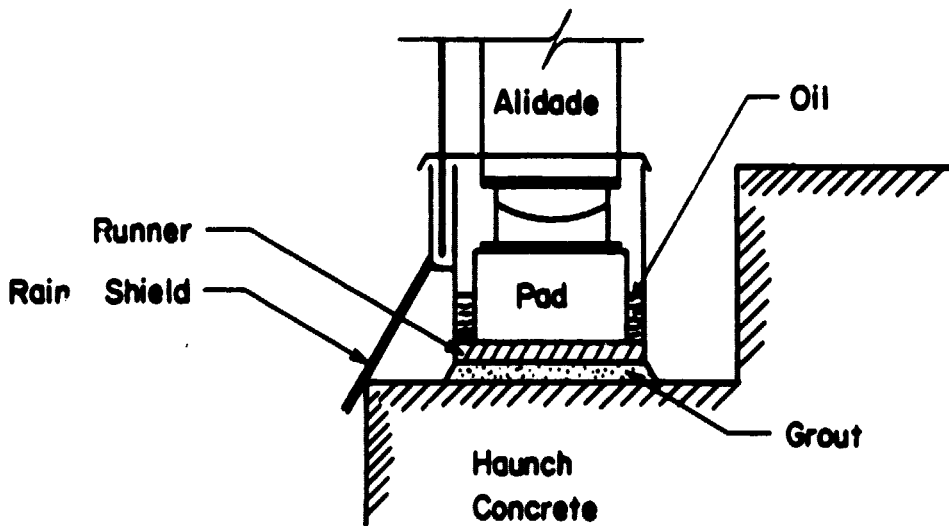


Fig. 3 Cross Section Through Hydrostatic Bearing

underside of the runner with resulting expansion and loss of "flatness." The original grout was removed after approximately two years of operation. Grout was removed by coring horizontally from the side. The original grout was replaced with dry packed Portland Cement material. The Portland Cement grout system performed satisfactorily for several years but eventually was replaced in local regions under the runner. Regions requiring repair are determined from instrumentation continually monitoring the bearing oil film thickness. When the film thickness is below a certain tolerance, re-grouting is performed. Re-grouting operations have been combined with extremely "fine tuned" shimming between the sole plates and runner.

In recent years, re-coring, re-grouting and re-shimming has become increasingly more frequent. The following information concerning the current condition of the grout-runner system and repair operations have been related by JPL personnel.

- (1) A survey by JPL indicates coring has extended several inches into the haunch concrete in approximately 40% of the perimeter of pedestal. Therefore, current grout thickness varies from the original 4 in. to approximately 7 in. in some area.
- (2) From examination of cored areas of haunch concrete, it was determined by JPL personnel that thin seams of soft sandy material are present in the top surface of the haunch area. This could be material that collected in shear keys in the top of the haunch and was not properly cleaned out prior to placing the initial grout.

Also, it is thought by JPL personnel that low areas remaining in the top of the haunch after initial casting may have been leveled off with lower quality concrete.

- (3) The oil reservoir around the pad continually leaks. It is hypothesized by JPL personnel that leaking oil partially infiltrates newly re-packed grout and inhibits proper development of grout strength. Also, leaking oil washes out grout material that has been ground at grout interfaces as a bearing pad passes over grout joints. Loss of this material reduces the stiffness of the grout-runner system.

Because of the increasing frequency of repair and the questionable quality of the material directly under the runner plate, JPL personnel decided to remove and rebuild a 12 in. layer of material under the runner. This would include 4 in. of grout and 8 in. of concrete. This repair work is scheduled to be conducted between June 6 and November 15, 1983.

It should be noted that a potentially major problem of aggregate reactivity is currently occurring within concrete throughout the pedestal structure. Evidence of alkali-silica reaction and associated cracking has been found in core samples taken in various regions of the structure. It is possible that expansion of reaction products is contributing to the need for frequent maintenance of the runner system. The alkali-silica reaction is potentially a global problem for the structure and

may require repair procedures significantly beyond the scope of the currently planned rehabilitation project.

The project currently planned is focused on re-establishing good quality material in the local region of the grout-runner system. The alkali-silica reaction problem is being investigated by CTL under a separate contract. Possible rehabilitation programs for this global problem will be included in a separate report.

JPL personnel considered the following factors to be important in development of the repair procedures:

- (1) Attainment of required strength.
- (2) Minimizing effects of water and oil on existing alkali-silica reaction.
- (3) Development of bond between old and new concrete and between new concrete and grout.
- (4) Performing the repairs within scheduled time and with minimum costs.

The following top surface repair procedures were proposed by JPL personnel:

- (1) Top surface concrete of haunch is to be removed to a uniform depth of approximately 8 in. below original top of concrete. (Approximately 2 in. below lower layers of horizontal reinforcement.) Concrete will be removed using a presplitting technique followed by secondary breaking. Presplitting will be performed using an expansive cement placed in a series of boreholes. Horizontal holes will be drilled into the side of the

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haunch, 8 in. down from the original top surface. Holes will be 1-1/2 in. diameter, 8 in. on center and 5 ft long. Every other hole will be filled with an expansive agent slurry. This procedure is intended to presplit an 8-in. layer of concrete along a horizontal plane. Secondary breakage and removal of concrete will be performed using hand held impacting equipment. Damaged reinforcing bars will be replaced using mechanical splicing.

- (2) The surface of existing concrete will be sandblasted to remove loose material and to expose aggregate. The surface will then be coated with an epoxy bonding agent (Concresive 1001 LPL or equivalent) and new concrete placed up to the original top of concrete elevation.
- (3) The runner plates will be dry packed in position with a 4-in. thick layer of either an epoxy grout or Portland Cement grout.

Objectives and Scope of Work by CTL

The proposed repair procedures were transmitted to CTL to accomplish the following objectives:

- (1) Evaluate proposed concrete removal techniques and recommend alternate techniques, if necessary.
- (2) Recommend type of materials and methods of placement for rebuilding the concrete and grout.

The objectives were accomplished within the following scope:

- (1) A site inspection of the antenna pedestal at DSS-14 was made.
- (2) Plans for the rehabilitation work were discussed with JPL personnel in Pasadena and at CTL's officer in Skokie.
- (3) Engineering drawings and photographs of the original construction were reviewed.
- (4) Proposed repair procedures were reviewed and critiqued by CTL engineering and material research personnel.
- (5) A literature review and discussion with persons outside of CTL with expertise in concrete removal techniques and use of expansive cement for presplitting were conducted.

REVIEW OF CTL SCOPE OF WORK

This section of the report describes work done by CTL under the particular items of scope.

Site Inspection

On March 2, 1983, R. G. Oesterle, B. J. Morgan and D. Stark of CTL visited the DSS-14 site at Goldstone and inspected the grout-runner system. A photograph of a typical region of the system is shown in Fig. 4.

As shown in Fig. 4, the top of haunch concrete has been "scaloped" by the horizontal coring of previous grout. The grout pad thickness varies from approximately 4 to 7 in. with abrupt transitions in thickness. A series of thin shim packs are placed between the "sole" plates and runner plate. The

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Fig. 4 Existing Grout-Punner System

"sole" plates bear on the grout. The shim packs are approximately 8 in. wide and are placed at approximately 10 in. centers. The entire area is covered with oil that has leaked from the hydrostatic bearing reservoir.

Meeting With JPL Engineers at Pasadena

On March 3, 1983, R. G. Oesterle, B. J. Morgan and D. Stark of CTL met with JPL personnel at their offices in Pasadena. Mr. Dale Wells of JPL described the proposed repair procedures. A short written description was transmitted to CTL on March 4, 1983. A copy of this description is included in Appendix of this report.

Review of Drawings and Photographs

JPL Structural Drawing J9435705 Sheet 1 of 17, Revision D dated December 1, 1977, was received and reviewed by CTL. Also, photographs taken during construction were reviewed. The drawing and photographs show reinforcement present in the top layer of the haunch region.

Other Meetings

During the week of March 7, 1983, repair procedures were individually described to selected CTL personnel knowledgeable in construction procedures. A meeting of this group was held on March 10, 1983 to critique the proposed procedures. Notes on this meeting are included in the Appendix of this report in interoffice correspondence dated April 4, 1983. The correspondence also contains notes on meetings held on March 11, 1983 at

CTL's offices in Skokie between D. H. McClure and H. P. Phillips of JPL and key CTL personnel.

Review of Concrete Removal Techniques

A recent report by U.S. Army Engineers⁽¹⁾ on concrete removal techniques was provided by CTL to JPL personnel. Also a recent paper on use of expansive cement⁽²⁾ was reviewed. A discussion of the behavior of expansive cement was held between R. Oesterle of CTL and the senior author of the paper, Professor C. H. Dowding of Northwestern University. A discussion on the use of hydraulic splitters was held between R. Oesterle of CTL and Mr. E. R. Langfield, President of the firm manufacturing the splitters.

REVIEW OF REPAIR PROCEDURES

Amount of Concrete To Be Removed

It is CTL's opinion that repairs can be performed by removing only the unsound concrete. However, CTL agrees that specifying removal to a consistent depth is advantageous for control of construction and planning. Also, replacement with a consistent depth of new material should be advantageous for operation of the hydrostatic bearing. A uniform layer of consistent material directly under the runner should provide relatively uniform strain through this most highly stressed region.

After removal of existing concrete, the exposed concrete may be saturated with oil. Therefore, bonding of new material to

old could be difficult. Cleaning procedures for oily surfaces have been included within specifications in the Appendix of this report.

Location of Horizontal Reinforcement

Reinforcement within a section of the haunch region to be repaired is shown in Fig. 5. Staff of JPL indicated that the 8 in. depth was chosen to permit removal of concrete down to approximately 2 in. below horizontal layers of reinforcement in the top surface of the haunch. Review of JPL photograph No. 033916 by CTL indicates that approximately 10 in. of material should be removed to be 2 in. below all reinforcement. This depth however would not alter any removal or replacement techniques.

Location of Vertical Reinforcing

A review of JPL Drawing J9435705 sheet indicates a vertical layer of No. 8 bars at 12 in. on-center near the outside vertical surface of the haunch. These bars can be located with an R-meter for positioning of boreholes. However, there is also a vertical layer of No. 11 bars at 12 in. on-center located approximately 17 in. in from the vertical surface of the haunch. Review of photographs indicates that the No. 11's do not line up radially with the No. 8's. These bars cannot be located with an R-meter. However, new radar techniques could be used to locate bars.

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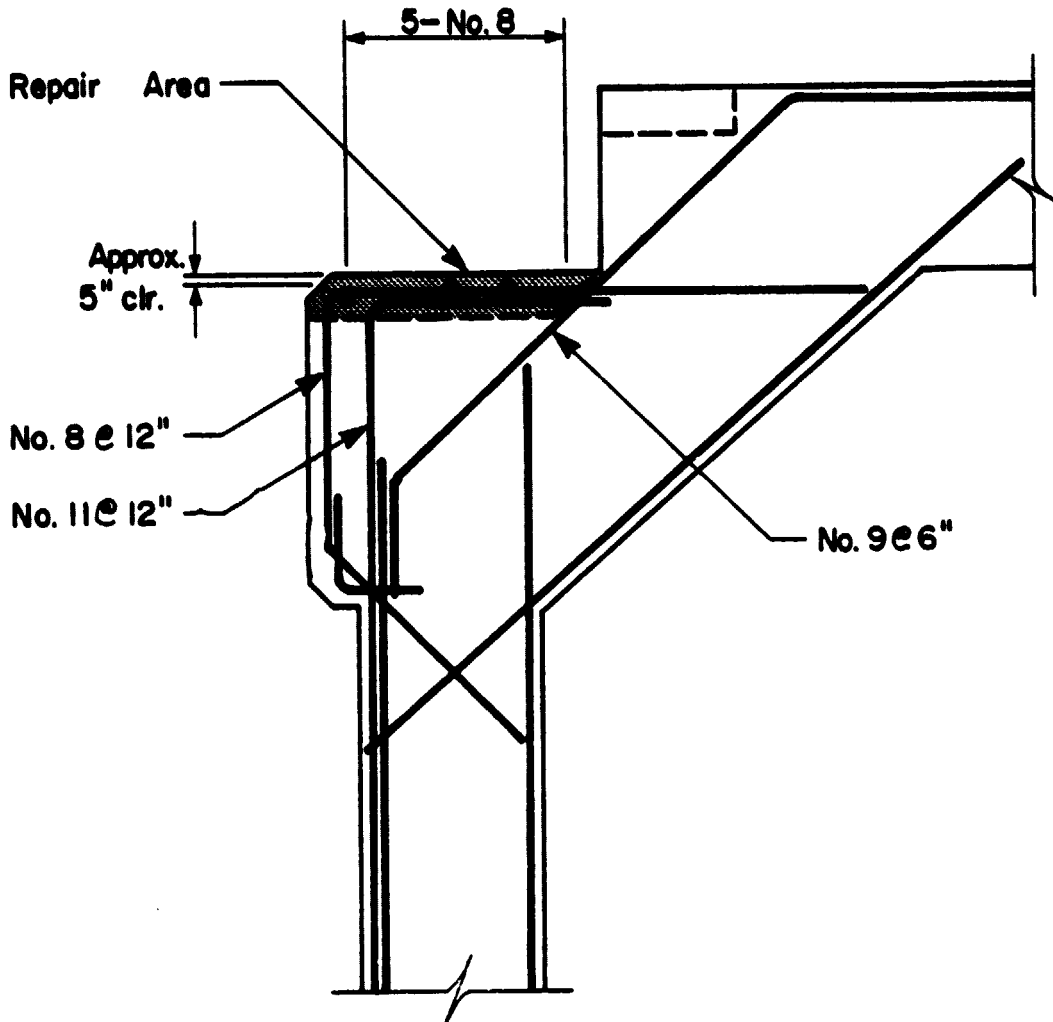


Fig. 5 Cross Section Through Haunch
Area Indicating Existing
Reinforcement in Repair Area

Method of Removal

Personnel of CTL agree that presplitting and secondary removal is a feasible technique for the proposed work. In general, concrete removal by presplitting can be accomplished with use of hydraulic splitters or use of an expansive cement. For removal of a shallow horizontal layer, hydraulic splitters are only capable of splitting a length of approximately 20 in. at a time. Since the layer to be presplit on the antenna pedestal is 60 in. wide, hydraulic splitters would not be practical for this application. Use of an expansive agent is a better approach.

An expansive agent can generate an internal pressure in the boreholes of approximately 7000 psi⁽²⁾. This pressure is adequate to fracture the concrete using 1-1/2 in. diameter holes at 8 in. on center with every other hole filled with expansive agent. However, because of the following considerations it is recommended that JPL personnel conduct trial use of the expansive agent presplitting techniques on a mock up of the the haunch area under conditions similar to those expected at DSS-14.

- (1) Expansive characteristics are very temperature sensitive. If used at low temperatures, it may take a couple of days to presplit the concrete, if it works at all. Heat generally accelerates the expansive reaction. However, effects of high temperatures are uncertain. It was stated that poor performance of the agent in a case history reported in Reference 1 might have been due to high temperature of the mixing water.

- (2) The expansive agent is used in a slurry that can be readily poured into vertical holes. Case histories found in the literature^(1,2) by CTL included examples of use only in vertical holes. It is recommended that JPL personnel experiment with techniques to place the material in horizontal holes. Care should be taken to completely fill and plug the hole.
- (3) Relatively large cracks are present in the haunch concrete. During the site inspection, oil was observed at a crack on the inside surface of the haunch. The oil had apparently seeped completely through the haunch concrete from the runner area. If boreholes intercept large cracks and allow the expansive agent slurry to seep into these cracks, damage to the haunch concrete may result. Therefore, it is recommended that boreholes be lined with a thin flexible sleeve to prevent seepage of the expansive agent.
- (4) Boreholes at 8 in. on-center should direct the splitting in a relatively horizontal plane. Boreholes 60 in. long should approximately intercept a diagonal layer of reinforcement. This weakened plane will direct the splitting up to the surface in the desired location. However, as reported in a case history in Reference 1, control of cracking between holes was difficult to achieve due to stress relief provided by weak material. Similar difficulty may be encountered

in the antenna haunch concrete if extensive micro-cracking has been caused by aggregate reactivity. It is, therefore, recommended that the outside face of the haunch concrete be "scribed" with a horizontal sawcut to assist in controlling the crack and producing a clean, uniform edge on the fracture plane.

Preparation of Existing Concrete Surface

After concrete has been removed, the surface of existing concrete should be roughened to expose clean aggregate. Light sandblasting is a suitable technique. However, care must be taken not to polish the surface. When large oil saturated surfaces are found, these surfaces should be cleaned. Techniques for cleaning are contained in the specification included in the Appendix of this report. It is not necessary to clean oil on surfaces directly adjoining a large crack. Possible lack of bond in the vicinity of large cracks will not be harmful and may be beneficial to performance of the new concrete overlay.

Bonding Agent

It is CTL's opinion that a grout consisting of Portland Cement and fine sand will perform as well as an epoxy for bonding new concrete to the old surface. Both materials require care in application. Similarly, both can become debonding agents if allowed to set sufficiently prior to placement of overlay concrete.

The amount of water involved in application of the Portland Cement bonding agent will not significantly change the aggregate

reactivity problem. Specifications for materials and procedures for the bonding agent are included in the Appendix of this report.

Replacement Concrete

New concrete for the overlay should be produced with good quality materials including non-reactive aggregate. The concrete should be placed in a manner to minimize cracking. Hot weather concrete placement techniques should be used. Specifications for materials and placement procedures are included in the Appendix of this report. Also, a trial mix design is included in the Appendix. The mix design will be finalized when 28 day properties are available.

In addition to proper use of concrete, adequate steel reinforcement should be used to minimize crack widths. The amount of circumferential reinforcement cross sectional area present in the existing concrete (5 - No. 8 bars at about 12-in. on-center) provides an adequate percentage of reinforcement for good distribution of cracking. However, efficiency of the reinforcement for controlling crack widths would be increased by using a larger number of smaller diameter bars. It is recommended that a layer of thirteen No. 5 bars placed with 2-in. cover and evenly distributed across the width of the new concrete be added. These bars will be equivalent to 5-No. 8 bars for strength but more effective for crack control.

Review of construction photographs indicates existing reinforcement was placed with a relatively deep cover (approximately 5 in.). Also, photographs indicate that several of the No. 8

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bars in the top layer of tangential reinforcement were not lap spliced. New tangential reinforcement should be adequately spliced. An adequate splice for No. 5 bars would be 20 in.

Replacement Grout

It is CTL's opinion that use of a dry packed Portland Cement or epoxy grout would be adequate for strength. However, CTL's experience in testing creep characteristics of proprietary epoxy grouts indicates that, although magnitude of total creep strain under sustained load may be similar in Portland Cement and epoxy grouts, the creep strain may occur at a significantly faster rate in the epoxy grout.

For a particular brand of epoxy grout tested with 1000 psi sustained stress at 77°F, final creep strain was on the order of 850 millionths. Approximately 50% of this strain occurred during the first 40 hours. Virtually 100% would occur in a 6 month period. This would result in a 0.0034 in. displacement in a 4 in. thick grout pad. This could be a significant displacement considering the extremely tight tolerance of the hydrostatic bearing film thickness. Therefore, it is recommended that the creep characteristics of the epoxy grout be investigated. Creep tests are currently being conducted by CTL. The results should be available shortly.

SUMMARY AND CONCLUSIONS

Comments and recommendations are summarized under Highlights at the beginning of this report. Specifications and trial mix design for replacement concrete are included in the Appendix.

Results of creep tests on epoxy grout and final concrete mix design will be available by approximately May 27, 1983.

REFERENCES

1. Campbell, R. L., "A Review of Methods for Concrete Removal," Technical Report SL-82-3, Structural Laboratory, U.S. Army Engineer Waterways Experiment Station, Vicksburg, April 1982, 59 pp.
2. Dowding, C. H., and Labuz, J. F., "Fracture of Rock with Expansive Cement," ASCE Geotechnical Journal, GT10, October 1982, pp 1288-1299.

APPENDIX

3
3/4/84

TO: H. Phillips
FROM: D. Wells
SUBJECT: Pedestal Concrete Removal

Drill 1 1/2" diameter holes on 8" centers to a depth of 5'. Holes to be drilled horizontally, approximately 8" below the top of the pedestal concrete (This is approximately 12" below the bottom surface of the hydrostatic bearing runner). Fill every other hole with the appropriate Bristar or S-Mite and fracture the concrete. To remove the concrete will require secondary breaking. Damaged rebar to be replaced using mechanical splicing.

Surface prep. sand blast to remove any loose material and to expose clean aggregate. Coat the surface using concrete 1001 LPL or equivalent and place new concrete of the specified mix.

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April 4, 1983

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To: R. G. Oesterle

From: B. J. Morgan

Subject: Notes of Meetings Concerning JPL Mars Antenna Pedestal Repairs

There were three meetings concerning the repair of the Mars antenna pedestal. The first meeting took place on Thursday morning, March 10. The second meeting was on Friday morning, March 11, and the third took place Friday afternoon, March 11. Notes on the Friday morning meeting will be given first since overall project background was discussed. Notes on the Thursday morning meeting will then be given followed by notes on the Friday afternoon meeting.

The Friday morning meeting was a formal meeting between JPL and CTL staff members. Those in attendance were - for JPL: D. H. McClure and H. P. Phillips; for CTL: W. E. Kunze, W. G. Corley, P. Klieger, E. A. B. Salse, H. G. Russell, D. Musser, R.G. Oesterle, D.C. Stark, and B. J. Morgan.* Don McClure from JPL explained the Mars antenna situation at Goldstone as follows. There are basically two decisions to be made concerning the antenna that are separate, but inter-related. The first decision is what to do about the apparently deteriorating concrete in the pedestal of the antenna. The second decision is how to phase the modifications of the diameters of the antennas at Goldstone, in Australia and in Spain. JPL would prefer to increase the diameter of the Goldstone antenna first since it is close to their design offices. However, the decision on which antenna to modify first must be made by June 1 of this year since all three antennas must be ready for tracking the Voyager space craft in 1986 as it flies by the planet Uranus. If there is no definitive answer concerning the degradation of the pedestal concrete in the Goldstone antenna by the middle of May, JPL will increase the diameter of the antenna in Australia first. After one year the question will be asked again concerning the degradation in the concrete in the pedestal of the Goldstone antenna. Hopefully, by that time a more definitive answer could be given and a decision made on what course of action to be taken.

*Respectively, Vice President, CTL/R&D Group; Divisional Director, Engineering Development Division; Consultant, Materials Research Department; Director, Structural Evaluation and Fire Research Department; Director, Structural Development Department; Director, Construction Methods Department; Manager, Analytical Design Section, Principal Petrographer, Materials Research Department; and Senior Structural Engineer, Analytical Design Section.

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The Goldstone antenna weighs on the order of 8 to 9 million pounds. It is supported on a hydrostatic bearing which rides on a film of oil approximately 10 mils thick. They have great difficulty maintaining proper oil film thickness and JPL feels this is due to basically two factors. The first is that the grout under the bearing runner did not cure properly because it was contaminated by oil as it was curing. This problem has been further compounded over the years by the continual shimming and adjusting of the runner to keep the bearing functional. The second factor is the reduction in modulus of elasticity in the main pedestal concrete due to aggregate reaction or other presently unknown causes. It is interesting to note that neither of the overseas antennas appear to have these difficulties. One of the reasons may be that the runners are 7 inches thick on the overseas antennas; the Goldstone runner is only 5 inches thick. Also, there is no indication of aggregate reactivity in the overseas antennas.

The area under the bearing will be repaired this year. The schedule for repair is as follows. From June 6 to November 15 the hydrostatic bearing will be reconstituted. From November 15 to January 15, 1984, the radial thrust bearing will be reconstructed. From January 15 to March 1 electronic tests of new electronic equipment will be conducted. They expect the antenna to be back in service by March 1, 1984, although there may be possibly two weeks of extension allowable beyond that time.

JPL plans to let contracts for the repair of the bearing runner by the middle of May. It is currently scheduled to remove concrete in the area of the bearing three weeks after the antennas become available on June 6. CTL asked if it would be practical to shore the disc from the inside during the reconstruction time. JPL answered that this would not be practical. The question was asked if it would be practical to do the reconstruction without supporting the entire antenna. JPL said that there would not be enough time to do it in this manner. In their opinion it would take longer to remove and replace concrete in segments underneath the runner than it would to just lift the antenna up and reconstitute the bearing all at once.

R. G. Oesterle
April 4, 1983
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JPL stated that the polymer grout that they are considering for use underneath the runner is essentially impervious to oil. Even mixing oil directly into the grout does not appear to cause difficulty in setup or curing. JPL stated that the outside temperature reaches 110° in the summer and can go as low as 25° with a 30-mile per hour wind in the winter. JPL states that if the concrete continues to deteriorate to the point where the antenna pedestal is no longer useful, JPL will have to remove and replace the entire pedestal. They are presently looking into ways of accomplishing this if it turns out that replacement is required. JPL stated that the polymer grout has the same modulus of elasticity as portland cement grout. Also, the Jodral Bank antenna in Great Britain has used polymer grout and it has performed adequately for the past 14 years. The runner at Goldstone is being shimmed generally every week to keep the runner and bearing alignment correct. JPL considers 25 years to be the required life for the antenna pedestal.

The following are notes made of the Thursday morning meeting. Those in attendance at this meeting were W. G. Corley, A. E. Fiorato, D. Musser, A. Litvin, E. A. B. Salse, R. G. Oesterle, D. M. Schultz and B. J. Morgan.*

The major points discussed were:

1. Well thought out procedures will be required to insure that the flowable Bristar properly fills the horizontal holes to be used to initiate splitting in the concrete.
2. Consideration should be given to the use of a hydraulic splitter.
3. A mockup would be appropriate so the contractor could practice splitting and replacement of concrete techniques before June 6.
4. All oil impregnated concrete of any substantial area should be removed even if below whatever depth they plan to go.

*Respectively, Divisional Director, Engineering Development Division; Director, Materials Research Department; Director, Construction Methods Department; Principal Engineer, Construction Methods Department; Director, Structural Evaluation and Fire Research Department; Manager, Analytical Design Section; Manager, Structural Experimental Section and Senior Engineer, Analytical Design Section.

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5. Vertical cores down through the launch would be advisable prior to June 6 to determine concrete conditions.
6. Shrinkage of new concrete against old will exist with accompanying cracking. All the standard precautions like using a low water/cement ratio should be used to minimize this. If superplasticisers are to be used, very careful consideration should be given to time of workability in hot weather.
7. This is definitely a hot weather concrete job and all the hot weather precautions should be taken. Insulation during curing may be called for to keep temperatures cracking down which potentially could be worse than shrinkage cracking.
8. Creep properties of the new grout to be used under the runner should be determined.
9. Instead of removing 6 to 8 inches of concrete all the way around, it may be sufficient to remove only to a depth required to reach sound concrete.
10. If substantially more concrete than 6 to 8 inches is to be removed, an analysis should be made of the remaining structural integrity of the haunch and disc area. Shoring of the disc from the inside may be required to maintain structural integrity if any major rework of the haunch is undertaken.

The third meeting on Friday afternoon was a more-or-less informal discussion of various ways and means of repairing the concrete pedestal. Those who participated in the discussions were McClure and Phillips of JPL and Oesterle, Salse, Musser and Litvin of CTL. CTL asked why remove 6 to 8 inches of concrete first. Why not just remove the concrete down to sound material. JPL responded by saying that this is the thickness recommended by the Bureau of Reclamation. Also, if they plan to remove 6 to 8 inches all the way around the pedestal, it is easier to plan and schedule construction because precisely how

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much to be removed is known ahead of time. On the other hand if they specify concrete removal down to solid or sound material, the construction is open ended and it is difficult to estimate how long and how extensive the work may be.

The present runner height must be kept within approximately 1/8 to 1/4 inch. CTL suggested that a large tool be used if dry-packed grout is to be utilized to make the packing of the grout more efficient. The area around the bearings, both the vertical bearing, and horizontal bearing, is not air-conditioned. Air is circulated in the area, however.

CTL offered to formulate procedures for the preparation of the surfaces to receive both the new concrete and grout. JPL indicated that it might be appropriate for CTL to prepare a number of specifications and procedures for the repair work. JPL also stated that they would like creep and aging tests for the polymer grout. CTL stated that we may have some creep data for polymer grout from a previous testing program. JPL stated that they will be using their mockup to check out grout placement and placement techniques. CTL suggested that it would be a good idea to mockup the actual reinforcement and concrete configuration for trials to develop the splitting technique before attempting to split the concrete in the pedestal.

In answer to the suggestion that it might be possible to increase film height as a permanent solution, JPL responded that film height can be increased in a essentially two ways. The viscosity in the oil could be increased or the oil flow could be increased which in turn would increase the pressure and film height. Crowning the pad has also been considered to compensate for increased deflection of the concrete.

BRUCE MORGAN
Analytical Design Section

BM/dh

SPECIFICATION FOR PEDESTAL CONCRETE REPAIR

CHAPTER 1 - SCOPE

This specification covers concrete repair for the pedestal supporting the 64 meter antenna at DSS-14, Goldstone, California. Topics covered by this document include materials, concrete mix and its production, formwork, concrete placement, protection and curing.

CHAPTER 2 - MATERIALS

2.1 CEMENT

All cement used in the concrete mix and bonding agent shall meet the requirements of ASTM C150 Type II, low alkali and moderate heat of hydration. Manufacturer's certification shall be furnished to JPL (Jet Propulsion Laboratory) for approval prior to start of work.

2.2 WATER

Water used in mixing concrete shall be potable, clean, and free from injurious amounts of oils, acids, salts, organic materials, or other substances that may be deleterious to concrete or reinforcement.

2.3 AGGREGATE

All aggregate shall be obtained from JPL - approved sources in the Lytle Creek drainage area near San Bernardino, California. No Mojave Desert aggregate shall be used.

2.4 ADMIXTURES

Water Reducing Admixture shall conform to the requirements of ASTM C494, and shall not contribute chloride ion in amounts that exceed corrosion thresholds recommended by ACI Committee 201 Guide to Durable Concrete. Admixtures shall be used strictly in accordance with the manufacturer's recommendations.

2.5 BONDING AGENT

Cementitious bonding agent shall consist of a 1:1 fine sand and portland cement grout, mixed with water to the consistency of thick paint.

2.5.1 Sand shall be obtained from a JPL-approved source as described in Paragraph 1.1.3 of this Specification.

2.5.2 All sand used in the cementitious bonding agent shall pass the No. 8 (2.36 mm) sieve. Ninety-five (95) percent of the sand shall pass the No. 16 (1.18 mm) sieve.

CHAPTER 3 - CONCRETE MIX

3.1 GENERAL

Concrete for the pedestal cap shall conform to all applicable requirements of ACI Standard 301-72 (Revised 1981) except as herein amended.

3.2 STRENGTH

The compressive strength of the concrete shall be a minimum of 5000 psi at 28 days as determined by "Test

for Compressive Strength of Cylindrical Concrete Specimens" (ASTM C39).

3.3 CEMENT CONTENT

Concrete shall contain a minimum of 564 lb per cubic yard of cement.

3.4 WATER-CEMENT RATIO

Water-cement ratio shall not exceed 0.45.

3.5 AGGREGATE SIZE AND GRADATION

Maximum aggregate size shall be 1 inch. Fine and coarse aggregate gradation shall conform to the requirements of the State of California Department of Transportation Standard Specification.

3.6 SLUMP

The concrete shall be proportioned and produced to have a minimum slump of 2 in. at the time of discharge into the forms. Slump shall be determined by the "Test for Slump of Portland Cement Concrete" (ASTM C143).

CHAPTER 4 - PRODUCTION OF CONCRETE

- 4.1 Ready mixed concrete for this work shall be batched, mixed and transported in accordance with "Specifications for Ready-Mixed Concrete" (ASTM C-94). Plant equipment and facilities shall conform to the "Checklist for Certification of Ready Mixed Concrete Production Facilities" of the National Ready Mixed Concrete Association.

4.2 TEMPERING AND CONTROL OF MIXING WATER

- 4.2.1 Concrete shall be mixed only in quantities for immediate use. Concrete which has set shall not be tempered, but shall be discarded.
- 4.2.2 When concrete arrives at the site with slump below that suitable for placing, as indicated by Paragraph 3.3 of this specification, water may be added only if the maximum permissible water-cement ratio is not exceeded. The water shall be incorporated by additional mixing equal to at least half of the total mixing time required.

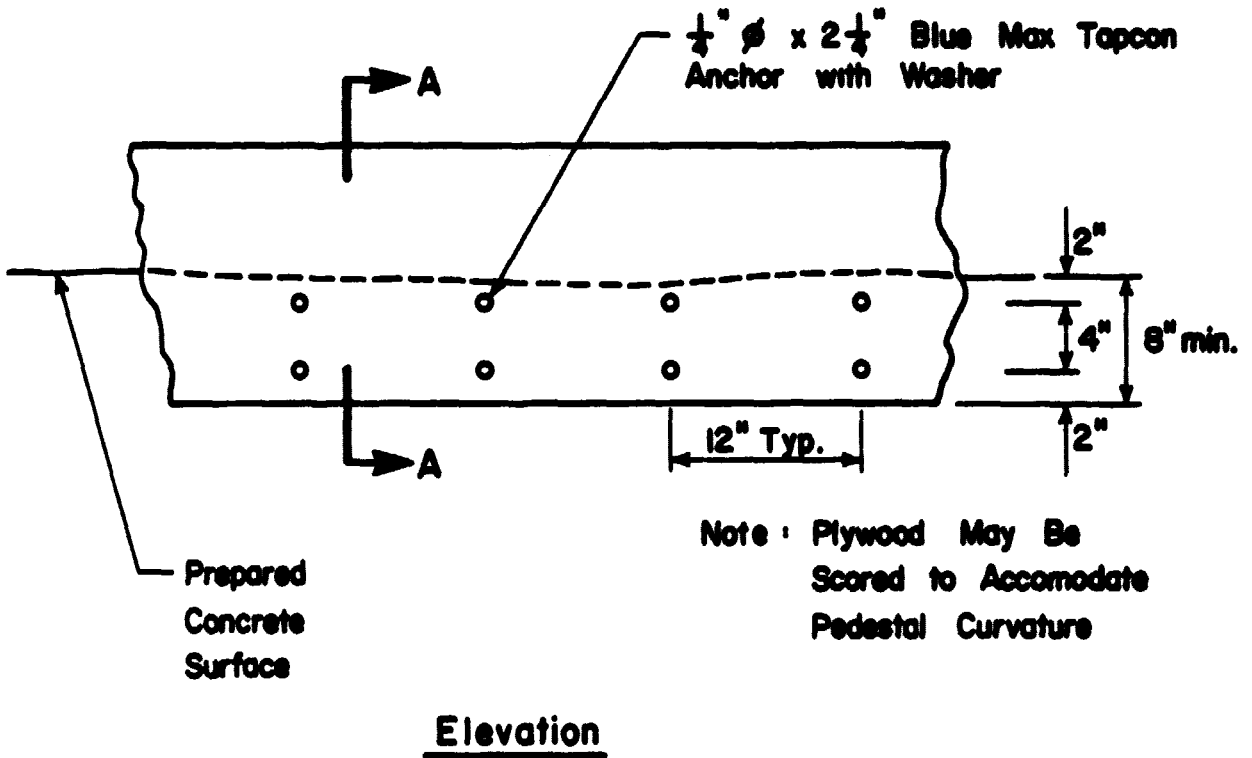
CHAPTER 5 - FORMWORK

- 5.1 Formwork shall be constructed of 3/4-in. thick Duraply or JPL-approved equal as shown in Fig. 1.
- 5.2 Plywood shall be fastened to the pedestal wall using the Blue-Max Tapcon fastening system. JPL will furnish the Blue-Max Tapcon screws, washers and installation equipment.
- 5.3 Plywood form shall lap down onto sound concrete a minimum of 8 inches.
- 5.4 The inside face of the form at the horizontal concrete surface shall be sealed to prevent leakage of mortar.

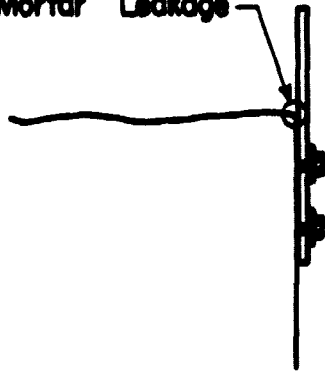
CHAPTER 6 - QUALITY CONTROL TESTING

- 6.1 Concrete shall be tested to determine strength and workability in accordance with methods outlined in Paragraphs 3.2 and 3.6 of this specification.

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Provide Sealant
Material Here to
Prevent Mortar Leakage



Section A-A

FIGURE 1. Pedestal Repair Formwork

6.2 Quality control testing will be the responsibility of a testing agency designated in the contract documents. The Contractor may, at his option and expense, engage a separate testing agency for his own information and guidance.

6.3 Testing will be performed in accordance with the requirements of Chapter 16 of ACI Committee 301 Report except as noted below. The Testing Agency will have the following duties:

6.3.1 Authority to recommended rejection of concrete to JPL not meeting the requirements of the approved design mix.

6.3.2 Confirm contractor's conformance with material requirements of this specification including verification of design mix.

6.3.3 Conduct strength, slump, and temperature tests of concrete on the following basis:

6.3.3.1 Three cylindrical test specimens shall be obtained and tested for each batch of concrete placed. Cylinders shall be made in accordance with ASTM Designation C 31, "Making and Curing Concrete Compressive and Flexural Strength Test Specimens in the Field."

6.3.3.2 Slump and temperature tests shall be performed at the time of concrete placement for each batch of concrete placed.

- 6.4 In addition to cylinders cured and tested under conditions required by Paragraph 6.3.3.1 of this specification, the Testing Agency shall prepare duplicate sets of three cylinders for each batch of concrete placed. These cylinders shall be field cured under conditions equal to curing for corresponding concrete placements. Such cylinders shall be tested at an age of 7 days.
- 6.5 All quality control test results shall be distributed to JPL and the Contractor.
- 6.6 If strength tests indicate that specified concrete compressive strength has not been attained, the Contractor shall make additional tests as required by JPL to determine the strength of concrete in place. In the event that such tests and subsequent analysis indicate that the work is not in conformance with this specification, JPL will require remedial or replacement measures as necessary. The Contractor shall bear all costs in connection with the added testing, engineering and remedial work.

CHAPTER 7 - CONCRETE PLACEMENT

7.1 SURFACE PREPARATION

- 7.1.1 Freshly exposed concrete surfaces shall be sandblasted with size 12 grit.

7.1.2 When oil saturated surfaces are encountered following sandblasting, these surfaces shall be cleaned as directed by JPL engineering staff using one of the following techniques:

7.1.2.1 Apply a soaking solution of one part trisodium phosphate in six parts water to the area. Immediately following application of soaking solution, cover affected area with a minimum 1/2-in. thick layer of a dry, powdered, absorbent inert material or portland cement and allow to dry for a minimum of 24 hours. Remove the dried paste and scrub the surface with clear water. Repeat this treatment as necessary.

7.1.2.2 Same procedure as 6.1.2.1 except use a soaking solution of 5% sodium hydroxide (caustic soda).

7.1.2.3 Same procedure as 6.1.2.1 using a benzene soaking solution, and allowing minimum 1 hr drying time.

7.1.3 Following sandblasting, the area to be repaired shall be blown clean with compressed air to assure that all loose particles have been removed. Following cleaning, all areas shall be closely inspected to make sure that all loose or hollow concrete is removed.

- 7.1.4 Prior to concrete placement, concrete surfaces and formwork shall be inspected and approved by JPL personnel.
- 7.1.5 Existing clean concrete surface shall be dampened prior to installation of concrete. Standing water in low spots shall be removed.
- 7.1.6 The cementitious bonding agent shall be scrubbed onto the properly prepared surface with a brush or broom to a thickness no greater than 1/4 in. Application of bonding agent shall occur within 1/2 hour of mixing time, and not more than 5 minutes prior to concrete placement.

7.2 CONVEYING

- 7.2.1 Concrete shall be handled from the mixer to the place of final deposit as rapidly as practicable by concrete bucket without segregation or loss of ingredients to maintain the required quality of concrete.
- 7.2.2 JPL will provide a crane and operator.
- 7.2.3 The bucket shall be of a size and design such that detectable setting of concrete shall not occur before adjacent concrete is placed. Conveying equipment shall be cleaned prior to placement operations.
- 7.2.4 Truck mixers, agitators, and nonagitating units and their manner of operations shall conform to

the applicable requirements of "Specifications for Ready-Mixed Concrete" (ASTM C94).

7.3 DEPOSITING

- 7.3.1 General - Concrete shall be deposited continuously from the bucket using a chute. If a section cannot be placed continuously, construction joints shall be located only as approved by JPL. Placing shall be carried on at such a rate that concrete which is being integrated with fresh concrete is still plastic. Concrete which has been partially hardened or has been contaminated by foreign material shall not be deposited.
- 7.3.2 Segregation - Concrete shall be deposited as nearly as practical to its final position to avoid segregation due to rehandling or flowing. Concrete shall not be subjected to any procedure which will cause segregation.
- 7.3.3 Consolidation - All concrete shall be consolidated by vibration, spading, rodding, or forking so that concrete is thoroughly worked around reinforcement, around embedded items, and into corners of forms, eliminating all air or stone pockets which may cause honeycombing, pitting, or planes of weakness. Internal vibrators shall have a minimum frequency of 8000 vibration per minute and sufficient

amplitude to consolidate the concrete effectively. They shall be operated by competent workmen. Use of vibrators to transport concrete within the forms shall not be allowed. Spare vibrators shall be kept on the job site during all concrete placing operations. Procedure for internal vibration shall be as specified in Chapter 7 of "Recommended Practice for Consolidation of Concrete" (ACI 309-72).

7.4 FINISHING

Following placement, the surface of the freshly placed concrete shall be struck off and screeded. The resulting concrete surface shall be level with the top of the form, with a tolerance of $\pm 1/4$ in.

7.5 PROTECTION

7.5.1 Unless adequate protection is provided and approval is obtained, concrete shall not be placed during rain.

7.5.2 Rainwater shall not be allowed to increase the mixing water nor to damage the surface finish.

7.5.3 Placing temperature - When the temperature of the surrounding air is expected to be below 40F during placing or within 24 hr thereafter, the temperature of the plastic concrete, as placed, shall be no lower than 55F. The temperature of the concrete as placed shall not be so high as to cause difficulty from loss of slump, flash

set, or cold joints and should not exceed 70F. When the temperature of the concrete exceeds 70F, precautionary measures approved by JPL shall be put into effect. Precautionary measures shall be provided in accordance with ACI Committee Report 305R-77, "Hot Weather Concreting" except as herein amended. When the temperature of the steel is greater than 120F, steel forms and reinforcement shall be sprayed with water just prior to placing the concrete.

7.5.4 To prevent thermal concrete cracking caused by rapid cooling of the structure during the night hours, and to prevent harmful thermal gradients from developing in the new concrete, one of the following insulating methods shall be used on exposed concrete surfaces for the duration of the curing:

7.5.4.1 Polystyrene insulation boards.

7.5.4.2 Insulating blankets.

CHAPTER 8 - CURING

8.1 GENERAL

Beginning immediately after placement, concrete shall be protected from premature drying, excessively hot or cold temperatures, and mechanical injury, and shall be maintained with minimal moisture loss at a relatively constant temperature for the period necessary for

hydration of the cement and hardening of the concrete. The materials and methods of curing shall be subject to approval.

8.2 PRESERVATION OF MOISTURE

8.2.1 For concrete surfaces not in contact with forms, waterproof sheet materials conforming to "Specifications for Waterproof Sheet Materials for Curing Concrete" (ASTM C171) shall be applied.

8.2.2 Curing shall continue for a minimum of 7 days.

Mix Design for Replacement Concrete

	<u>lb/cu yd</u>
Cement - Type II Mod.	611 (6.5 bags/cu yd)
Net Water	263 (W/C = 0.43)
C.A. (No. 3+No. 4) Gravel From Lytle Creek	1905 Dry wt
F.A. (from Lytle Creek)	1240 Dry wt

Properties of Plastic Concrete at 70°F

Net Air Content	1.5%
Slump (initial)	2.0 in.
Slump + 30 min	1.0 in.
Slump + 90 min	1.0 in.
Unit wt	149.8 lb/cu ft

Use super plasticizer added at job site to improve workability.

Use recommended dosage to bring slump into the 4 to 6 in. range.

Added workability from use of plasticizer should last for 20+ minutes.

Redosage after slump loss from first dosage of superplasticizer should restore slump back to 4 to 6 in. range for additional 20+ minutes.