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Arecibo Observatory
Stabilization Efforts

WJE PROJECT NO. 2020.5191

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Engineering efforts have been underway to reevaluate the structure and reexamine options going forward after the November 6, 2020 failure of the M4-4 cable. Despite the many uncertainties regarding critical structural elements, WJE believes there is a possibility to save the structure without undue risk to workers. The key element in pursuing this path is reducing structural uncertainty to acceptable levels by demonstrating that key elements have the capacities needed to support the work that must be done.

It is apparent from the failure of M4N in August 2020 and M4-4 more recently that cable or socket capacity degradation has taken place over time. Thus, the ultimate capacities of the cables supporting the structure are currently unknown. We recognize that because of the unknown capacity of critical elements of the structure and the difficulty associated with executing their repair, demolition of the facility is an option if attempts to repair it cannot be pursued. However, we believe repairs are possible if stabilization efforts commence immediately. Therefore, we have developed a plan that starts with immediate reduction of load in all cables with the goal of obtaining a 10 percent demonstrated margin of capacity for each cable. We anticipate, however, that the load reduction process may not achieve this margin. Select cables will therefore require load testing to prove an appropriate margin. However, this does not necessarily mean that the load must be increased in the cables by 10 percent. For example, a cable carrying 100 kips whose load is reduced to 94 kips as part of the load reduction efforts would have shown a 6 percent reduction in load. In order to prove a 10 percent margin on 94 kips, the proof load would be 103 kips, which represents an increase of 3 percent over the current load.

Demonstrating adequate capacity for a given task may increase the risk of structural collapse (e.g., by temporarily increasing the load on critical elements). Of course, any such demonstration would be done without personnel in threatened positions. In short, risks during occupied times can be kept reasonably low by performing higher risk demonstrations while the structure is not occupied. Since the alternative to repair is demolition of the facility, the risk of possibly collapsing the unoccupied structure during an attempt to save it may be acceptable. Of course, if the requisite capacity cannot be successfully demonstrated at any time, risks to occupants would be excessive and repair efforts would cease, leaving demolition as the only option. In our opinion, areas threatened by a collapse of the structure should only be occupied if the Tower 4 cable group has a demonstrated capacity that is at least 10 percent greater than the demands that exist during occupancy.

As time passes, the capacities of the cables will decrease as evidenced by the two recent failures. In order to maintain a demonstrable 10 percent reserve capacity, the initial load reduction efforts may have to be supplemented by load testing. For example, if load reduction cannot keep up with a conservative estimate of strength loss, it may be necessary to demonstrate that adequate capacity remains by temporarily applying loads. When done properly, such proof testing can be used to demonstrate capacities, which is why load testing is a staple of the engineering profession. Such testing is done because there is uncertainty regarding the system's strength; hence there is a possibility that the structure will collapse during a test. As noted previously, this risk is taken on (while the structure is not occupied) so as to reduce the risk of collapse while it is occupied. And, since the alternative is destroying the structure, the risk of failure during a load test may be acceptable.

The following outlines activities designed to establish a 10 percent reserve capacity in the Tower 4 main cables so that work within the backstay anchorage perimeter including on the feed platform can be done.

Immediate Priority Tasks

Task 1 – Tower 4 Backstay relaxation. At the tower anchorages, all seven backstays will be relaxed in a sequenced approach to relieve load in the main cables. The tower top will move inward about 18 inches during this process, which will lower the main cable forces by about 2 percent. This work can be completed without subjecting personnel to hazards associated with an additional cable failure.

Task 2 – Towers 12 and 8 Backstay relaxation. Similar to the work carried out at Tower 4, the backstays at Towers 12 and 8 can be relaxed. This will further reduce the loads in the Tower 4 main cables by an additional approximate 2 percent.

Task 3 – Installation of 7/8-inch Wire Rope. Based on the possible availability of equipment currently at the facility, a 7/8-inch diameter wire rope will be connected to the pin at the platform connection of the M4 cables using a properly rated fabric sling. The cable will run to the top of Tower 4 and be redirected to a winch anchored near the tower base. The work to install the cable and hardware will utilize a helicopter. No personnel will be on the platform or top of tower. Installation of the wire rope will reduce the tension in the Tower 4 cables by about 2 percent

Task 4 – Cutting of Hanging M4-4 Cable. Using a helicopter, the failed M4-4 cable will be cut from its connection to the platform. This will reduce the load in the M4 cables by about 0.8 percent.

Task 5 – Removal of Azimuth Counterweight. There is currently about 45,000 pounds of lead counterweight positioned on the top of the azimuth structure. Most of the lead is in slabs weighing approximately 200-lbs each. An attempt will be made to throw the lead from the azimuth using workers positioned from a helicopter. If this is not successful, then some other method to remove the counterweight is needed that does not place personnel on the platform. Removal of the lead counterweight is estimated to reduce the M4 forces by 4 percent.

Additional Tasks. If Tasks 1 through 5 are successful and the load in the M4 cables is reduced by approximately 10 percent, limited and controlled access onto the platform and space below the reflector dish will be permitted. Additional tasks to be completed during this period would include the following:

1. Removal of the Gregorian dome hurricane stow pin
2. Movement of the Gregorian dome to a position on the current azimuth that further reduces the M4 main cable tensions
3. Repair of the tie-down anchors to improve load testing capabilities
4. Install two 55-mm temporary cables between Tower 4 and the platform that will replace the capacity lost by the failed main cable
5. Periodic load testing of the system to confirm the margin of safety has not been diminished by continued degradation of various cables/sockets

If the immediate priority tasks listed above cannot all be completed, hold-down cables will be used to load the system to the extent necessary to provide at least a 10 percent reserve capacity upon removal of the hold down load.

With the additional tasks completed, we are confident the stability of the structure will no longer be compromised by the failure of an additional M4 main cable. Restoration and investigative work can then safely proceed with the original plan.