

## **s'MASH Impulse Response Testing Cases**

### ***1. Debonding of concrete bridge deck overlay***

An existing reinforced concrete approach ramp to a freeway has been overlain with a 75-mm thick silica fume unreinforced concrete. Surface cracking appeared six months after construction, with debonding of the overlay becoming apparent at certain locations on the slab. s'MASH testing was brought in to determine the exact extent of the debonding using the mobility contour plot for the whole deck. Testing was completed in three hours, minimizing traffic closure. Additionally, an estimate of those areas of the deck with incipient debonding problem was made by analyzing the s'MASH stiffness and mobility slope contour plots. This facilitated the decisions to be made for the repair solution and the quantity of deck overlay to be replaced.



### ***2. Prestressed concrete box beam bridge***

A common form of prestressed beam bridge structure relies on cross-rods and grouted keyways between the beams to form a single span bridge. Each hollow core beam is usually between 20 and 30 m long and 900 mm wide. s'MASH tested one of these bridges through a 100-mm thick concrete overlay, with much greater mobility and lower stiffness on one half of the bridge. In the half of the bridge with higher stiffness the transverse rod system is functioning as designed. However in the other half of the bridge the opposite is true; either the transverse rod system was not properly installed or not present. It was reported that during recent renovation of the bridge, the crew had problems with one of the rods. s'MASH testing showed the ability of the method to detect changes within the bridge, such as a loss in functionality of the transverse rod system. This loss in the rod system can be detrimental to the overall load carrying capacity of the bridge. The speed of the s'MASH testing makes it a valuable tool for testing other similar bridges.



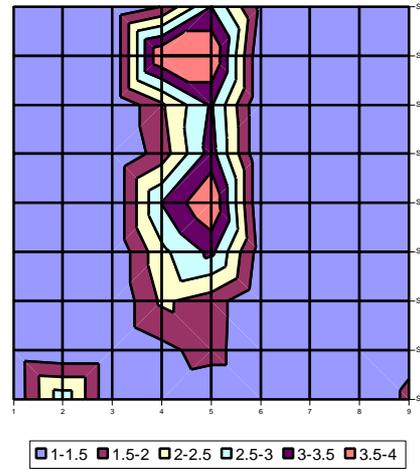


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**3. Concrete slabs: poor support and low density**

The s'MASH test evaluated a 9600 sq m industrial reinforced concrete floor slab for the presence of poorly consolidated areas, as well as voiding in the slab sub-base. The slab design thickness for the entire area tested was 200 mm. The s'MASH mobility and stiffness contour plots indicated areas with probable slab thickness less than 200 mm. Coring of select locations and impulse radar traverses correlated overall floor slab thickness with core thickness. The s'MASH Voiding Index when >2 showed voided/poor support areas beneath the slab. S'MASH also identified an area of potentially honeycombed or voided concrete. This was confirmed by coring at selected locations. In addition, areas of lower stiffness were located by s'MASH along construction joints, which is typical of jointed slabs on grade. Fieldwork was completed in 3 days!

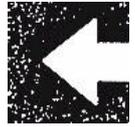
Industrial Floor, 40 m x 40 m Section  
Voiding Index



**4. Poor concrete consolidation in cement silos**

Two 60 m high x 30 m diameter cement silos were being constructed by the slip-form technique. Low density and honeycombed concrete was observed on the silo surfaces immediately above the interior silo ring beam at 20 m above ground level when the forms were raised. The concrete on the interior and exterior walls immediately above and below the steel ring beam was tested by s'MASH, as well as the concrete at the level of the steel ring beam on the silo exteriors. No areas of high s'MASH mobility and/or mobility slope were detected in areas of visibly sound surface concrete. No delamination of the concrete along reinforcement planes was observed from the test results. It was concluded from the s'MASH testing that the concrete in the walls was sound and integral, apart from those areas where rock pockets and tear cracks were readily visible on the concrete surface. Cores were taken in the concrete above the ring beam, including one core through a visible tear crack. All the cores contained sound, continuous concrete, confirming the s'MASH test findings.





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### **5. *Honeycombing in cooling tower wall***

A mechanical-draft cooling tower with four cells included 300-mm thick reinforced concrete walls 15 m high. The walls were lined with 2-mm thick plastic coating to prevent excessive water loss through the concrete. After 2 years in service, blisters were observed on the walls, and when pierced, showed zones of saturated, poorly consolidated concrete. s'MASH testing of the concrete through the lining mapped out zones of honeycombed concrete, and gave an accurate estimate of repair quantities. All zones with poor concrete consolidation located by s'MASH were confirmed during the repair program when the old liner was removed. The speed of testing and analysis meant that no facility downtime was necessary, resulting in great savings for the owner.



### **6. *Cladding on high-rise buildings***

Vertical cracking distress was observed in terra cotta clad column covers and mullions on the Wrigley Building, Chicago. s'MASH tests were conducted from the 4th to the 13th floor. The tested column and mullion were representative of similar elements around the entire perimeter of the building where the problem of vertical splitting or cracking of the terra cotta cladding was confirmed. Features such as debonding of the unit from its supporting back-up masonry, and non-visible internal delamination or splitting within the terra cotta unit were detected by s'MASH. The stiffness recorded for each terra cotta unit was plotted versus the position or height of the unit from the 4th floor upward. For the column cover, the residual stiffness measurements indicated very strong concentrations of high compressive stress directly above and below the position of the steel shelf angles supporting the terra cotta at each floor line.





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**7. Leakage in fluid-containment concrete tanks**

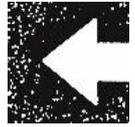
A 180 m circumference by 5 m high aeration tank showed water leakage at cold joints. s'MASH testing of the tank walls was used to locate and quantify the extent of any hidden poorly-consolidated pockets that could have an effect on the engineering performance of the structure. Those areas considered to have the lowest degree of concrete consolidation were located, and selected cores were taken. The s'MASH test responses showed minimal evidence of poor consolidation, with no significant areas of low density or honeycombing. Low-density patches were limited to superficial areas, particularly at the base of the tanks. All the cores taken at test points with the highest recorded values of the product of s'MASH slope x mobility showed sound concrete. It can be concluded from the s'MASH analysis that any areas of poor consolidation had already been identified at the tank surfaces.



**8. Evaluation of old closed spandrel arch bridge**

The bridge was built in 1907, and the spandrel arches are approximately 25 m wide by 25 m long. Preliminary information suggested that the arches are approximately 1.1 m thick at the spring line, decreasing to 600 mm thick at the soffit, and that they are filled with soil to form the subgrade for the flexible paving bridge deck. The concrete in the piers had been placed in wooden forms in approximately 300 mm lifts. The undersides of the arches showed spalling of concrete in places, particularly along construction joints in the bridge alignment, and in zones along the water line. Water was seeping through these spalled zones, presumably from the soil fill below the deck. The three s'MASH parameters of mobility, dynamic stiffness and mobility slope revealed areas of poor compaction and honeycombing, as well as delamination of the surface concrete around the reinforcement. The condition of the concrete in the arches was shown to be good, given the age of the structure, and the core compression strengths were lower than normally encountered.





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**9. Evaluation of the anchor quality of granite panels.**

In a pilot Study the anchor quality of granite panels to steel frame of a high rise building was evaluated.

The granite panels had been fastened to the steel frame by means of 6-8 epoxy anchors. Holes had been drilled into the panels to half depth of the thickness, the anchors epoxied in the holes and subsequently fastened to the steel frame.

By means of the dynamic stiffness and the average mobility the s'MASH classified the panels in three groups: loose panels, panels without regular anchoring and well-fastened panels.

The test results were confirmed subsequently by visual inspection of the anchors from the inside of the building.

