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TABLE 1--TEST LOADS AND LOADING AREAS

Grade of cover	Load in tons	Diameter of loading block (inches)
HD	35	12
MD	5	4
LD	1	12

TABLE 2--TEST RESULTS OF MD SQUARE COVERS

Cover Mark	Bars	Fibres	Ultimate load (tons)	Concrete strength of 15 cm cubes (kg/cm^2)
MD1	Nil	0.5	3.75	350
MD2	Nil	0.75	4.08	350
MD3	12 mm 5 Nos.	Nil	6.00	350
MD4	12 mm 4 Nos.	Nil	5.03	300
MD7	12 mm 4 Nos.	1.0	8.30	300

TABLE 3--TEST RESULTS OF MD CIRCULAR COVERS

Cover Mark	Bars	Fibres	Ultimate load (tons)	Concrete strength of 15 cm cubes (kg/cm^2)
MD1	Nil	0.5	2.70	350
MD2	Nil	0.75	3.67	350
MD9	10 mm 5 Nos.	Nil	5.55	360
MD10	10 mm 5 Nos.	1.0	8.60	360

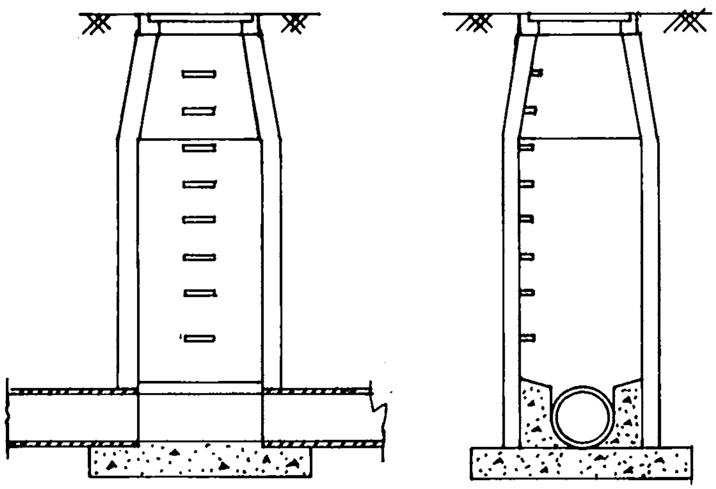

Fig. 1--Typical manhole

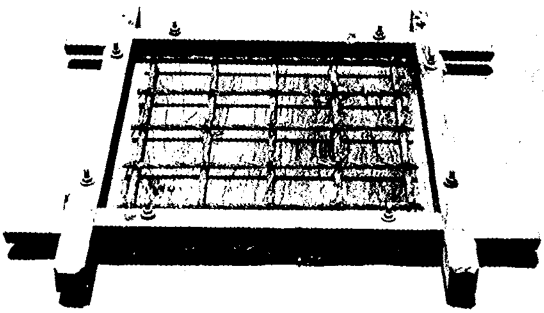

Fig. 2--Mold for casting medium duty square cover

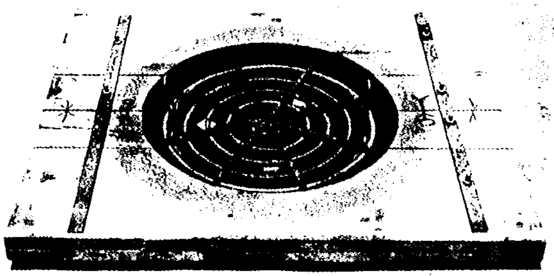

Fig. 3--Mold for casting medium duty circular cover

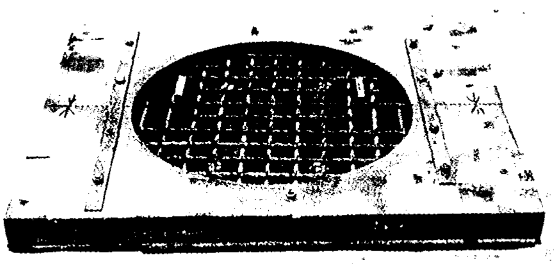

Fig. 4--Mold for casting heavy duty cover

Fig. 5--Testing frame for HD cover

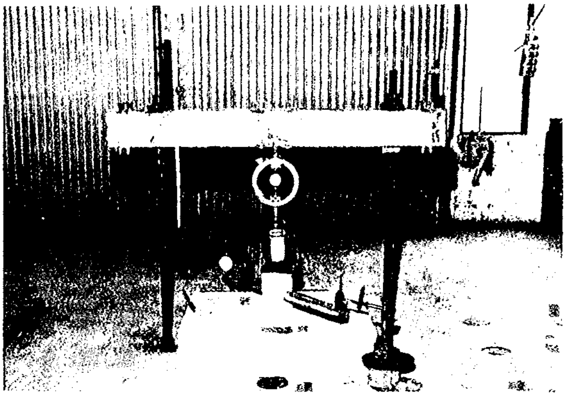

Fig. 6--Testing arrangement for MD cover

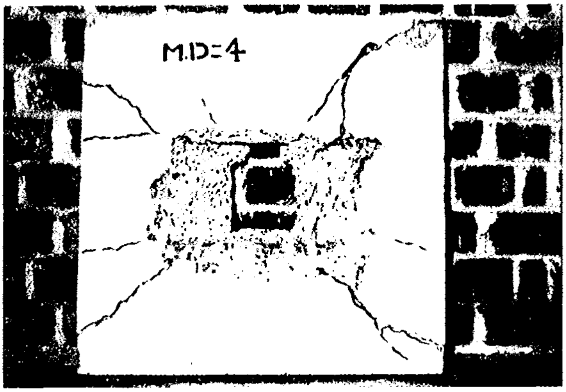

Fig. 7a--Underside of MD-4 cover after failure

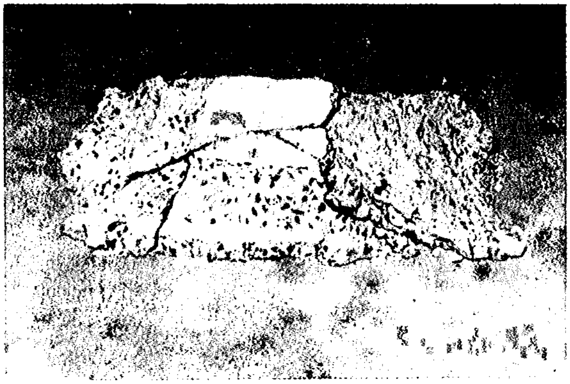

Fig. 7b--Pyramid of concrete punched out of MD-4

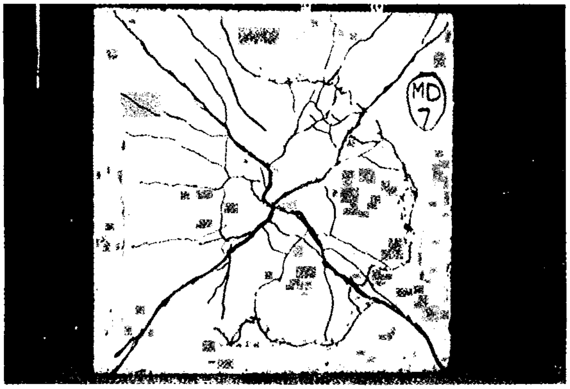

Fig. 8--Underside of MD-7 after failure

Fig. 9--Topside of HD cover after failure

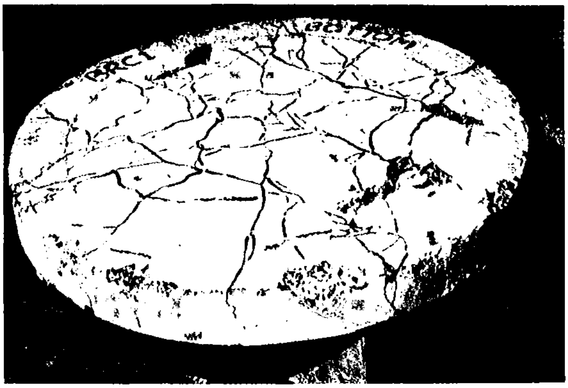

Fig. 10--Underside of HD cover after failure

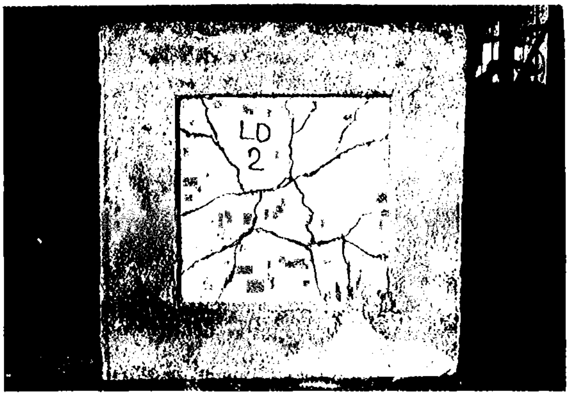

Fig. 11--Underside of LD cover after failure

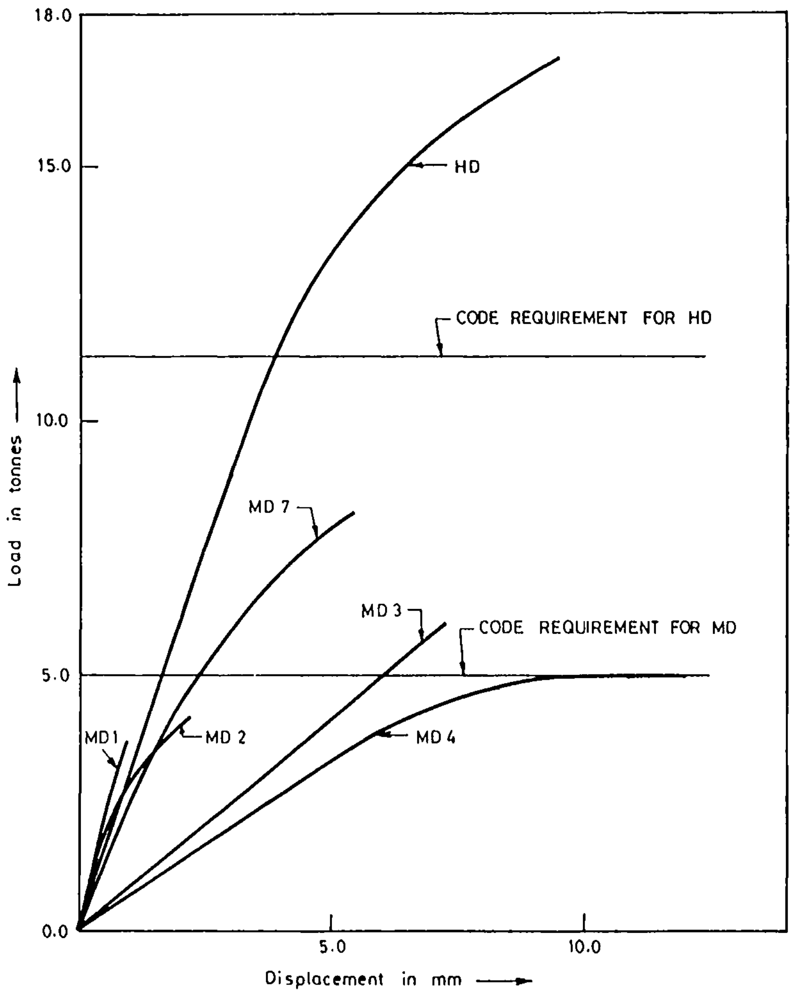

Fig. 12--Load displacement curves

SP 105-23

Navy Experience with Steel Fiber Reinforced Concrete Airfield Pavement

by G. Wu and M. Jones

Synopsis: This paper presents the U.S. Navy's experience with the performance of steel fiber reinforced concrete airfield pavements, and techniques evaluated to alleviate the problem of exposed surface steel fibers. The exposed surface steel fibers posed a potential foreign object damage hazard to jet engines, and injury hazard to ground support personnel. The Navy has elected to use the standard Navy PCC slab size (12.5-ft by 15-ft) and thickness for SFRC pavements because of slab curling and corner cracking problems on SFRC pavements. The diamond blade bump grinding technique is preferred for removing surface steel fibers because of its cost and life expectancy.

Keywords: airports; concrete pavements; fiber reinforced concretes; grinding (material removal); metal fibers; performance; structural design

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INTRODUCTION

Background

The U.S. Army Corps of Engineers conducted a study on steel fiber reinforced concrete (SFRC) in the early 1970s. The study included controlled, accelerated traffic tests, and field tests on SFRC and Portland cement concrete (PCC) pavements. The results of the study indicate that SFRC pavements will perform better than plain concrete pavements, will result in thinner pavements, and can be produced and placed with conventional paving equipment and techniques (Ref 1). Other advantages of SFRC include higher flexural, tensile, and fatigue strengths; and greater resistance to cracking, spalling, abrasion, impact, and thermal shocks. The improved properties of SFRC may allow using larger pavement slabs and fewer joints than that of PCC. Since that study, ten commercial airports and two military airfields have used SFRC as pavement materials.

With the expectation that SFRC airfield pavement will out-perform conventional PCC, the Navy constructed SFRC overlays for aircraft parking aprons at Naval Air Station (NAS) Fallon, Nevada and NAS Norfolk, Virginia. The original old pavement on the aircraft parking aprons at NAS Fallon and Norfolk were conventional PCC 7.5 to 8.5 inches thick and 7 inches thick, respectively. In all Navy SFRC constructions, an asphalt concrete leveling course was applied before placing the SFRC overlay. The thickness of the SFRC overlay was 5 inches at NAS Fallon, and mostly 5 inches at NAS Norfolk. The size of the slabs ranged from 25-ft by 40-ft at NAS Fallon to mostly 25-ft by 25-ft at NAS Norfolk. In comparison, the Navy standard PCC slab size is 12.5-ft by 15-ft. Slip-form pavers were used for the SFRC overlays.

Neither project was completely successful. Pilots at NAS Fallon complained that loose surface steel fibers could become a source of jet engine foreign object damage (FOD). There were also some premature corner cracks at both NAS Fallon and Norfolk.

PROBLEMS WITH SFRC AIRFIELD PAVEMENTS

Exposed Surface Steel Fibers

In most military and commercial airports the finishing techniques for the SFRC pavements produce a surface with partially embedded steel fibers (Figure 1). These partially embedded steel fibers later disbond due to traffic or weathering. The loose steel fibers present potential personnel safety and aircraft FOD hazards. Exposed and disbonded steel fibers are of particular concern to the Navy because Navy aircraft are more susceptible to FOD hazard due to the close proximity of engine intakes to the pavement surface, and the close proximity operation of multiple aircraft. The exposed surface steel fibers may also cause vehicle or aircraft tire punctures, and cuts or scrapes to ground support personnel.

There were two phases of SFRC construction at NAS Fallon. In the first phase, the final broom finish dislodged the deformed end steel fibers and left them loosely cemented to the surface. Wire bristle and magnetic sweepers were used to remove the surface steel fibers before the apron was opened to traffic. This operation was only partially successful.

For the phase 2 work, the specifications were modified to place limits on the number of visible surface steel fibers, and to require the use of a "rollerbug" concrete finishing tool (Figure 2) to depress the steel fibers beneath the concrete surface. Although a few isolated clusters of surface steel fibers were found, these changes yielded a satisfactory surface over most of the aircraft parking apron area.

FOD hazard is not a major concern at commercial airports because the engine air intakes on commercial aircraft are substantially higher than those on military aircraft, and commercial aircraft do not take off in formations. In general, commercial airports have not had complaints about partially embedded surface steel fibers, and no attempts have been made to remove such fibers. At Salt Lake City Airport, some airlines wanted to perform "power-back" from the gates. The power-back operation could present personnel injury hazards from airborne steel fibers.

Slab Curling and Corner Cracks:

Slab curling is more pronounced in SFRC pavement than in conventional PCC because the thickness of the SFRC pavements are usually 50 to 80% of that of PCC. A typical example of slab curling is illustrated in Figure 3. Corner cracks, shown in