CHAPTER 3

EXPERIMENTAL INVESTIGATION

3.1 General

Composite slab specimens of three different configurations were tested in this study to find out configuration with highest shear carrying capacity. Shear transfer capacity was determined by “push tests” on deck-slab specimens, the details of which are given in Fig.3.1. The overall thickness of a specimen is about 150mm-155mm, depending on the exact concrete clear cover to be provided.

Conventional headed shear connectors’ shear carrying capacity increase with concrete grade and concrete top cover. Therefore, in this study different concrete grades and concrete top covers were used to find out shear carrying capacity with new three configurations. In Sri Lankan construction industry practical concrete grades with slabs are grade 20 and 30. The economical concrete top covers are 20mm and 25mm. Therefore, for each configuration concrete grade 20, 30, 45 were used with concrete top cover 25mm to check the effect of concrete grade on shear transfer capacity. Similarly concrete top cover 20mm, 25mm, and 30mm were used with concrete grade 30 to check effect of concrete top cover on shear transfer capacity. In each case three replicates were tested to verify the results. With configuration 3, position of shear stud was changed with filled steel tube and empty steel tube. All together forty five samples were tested for all three configurations and effect of configuration on shear transfer capacity also checked.

The proposed “push test” has a single span arrangement with only one deck slab specimen, as opposed to “standard push tests” described in Standard Codes of Practice (Olgaard et al 1971) for conventional composite arrangements where two identical deck slab specimens to be fixed on either side of the main steel beam. The major reason for that is the proposed configurations are not containing open flange steel beam sections. A considerable amount of material saving is also expected by the proposed arrangement. A similar arrangement has been successfully used for push out tests in the past (Grant et al 1977). The testing arrangement is illustrated in Figure 3.2.The proposed single span push out test rig provides additional means of maintaining verticality of the deck slab specimens during loading, as shown in Fig. 3.2(b).

3.2 Test Specimen Configurations and Preparation

3.2.1 Configuration – 01

In this configuration shear transfer capacity of composite slab relies on contact between steel tube and concrete. In other words friction force between steel and concrete enhances the shear transfer capacity of composite slab in configuration 1 which is different from conventional headed shear studs in configuration 3.

All push out slab specimens were constructed using wooden forms. Each specimen consisted of concrete filled steel tubes, each of which was welded to a 200mm wide x 950mm long x 9mm thick steel plate. Two “S” shape flashings (25mm x 50mm x 20mm) riveted to two steel profile sheets, were riveted to steel plate as shown in Figure 3.1 (a),to avoid bleeding through intersection joint at steel tube and deck.

The concrete filled steel tube was welded to steel plate prior to concrete filling. Then it was filled by concrete and concrete test cubes were cast at the same time. Concrete test cubes were placed without curing, but with proper covering.

Two layers of steel reinforcement (R6@200c/c) were placed top of the steel tube to control cracking. Mortar cover blocks were used to support the reinforcement. Silicon was applied to fill the openings. All slabs were cast horizontally. After the concrete was placed in the forms, it was vibrated with a mechanical vibrator. Steel tube was filled with concrete prior to slab panel concreting.

The specimens were covered and moist-cured for seven days, at which time the forms were removed. Concrete test cubes were cast along with the specimens and cured similarly.

The push-out specimens were placed as shown in Figure 3.2 and then those were tested 28 days after being cast. At that time both concrete test cube samples were tested.

3.2.2 Configuration – 02

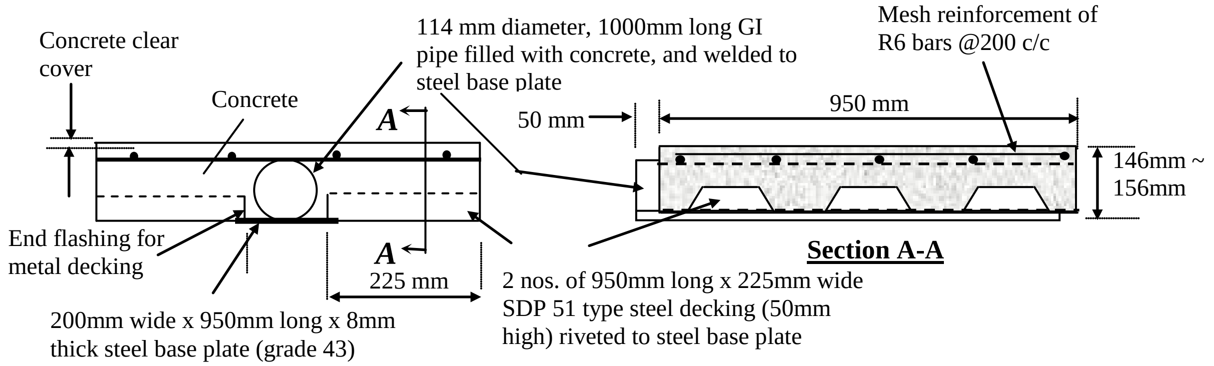
In this configuration shear transfer capacity of composite slab relies on steel strips which were oriented and welded either side of the tube. In other words friction force and mechanical bond between steel and concrete enhance the shear transfer capacity of composite slab in configuration 2 which is different from conventional headed shear studs in configuration 3.

All push-out specimens were constructed similarly to the Configuration – 01. But, 25mm x 8mm two steel strips were welded to steel tube before filling with concrete, as shown in Figure 3.1(b).

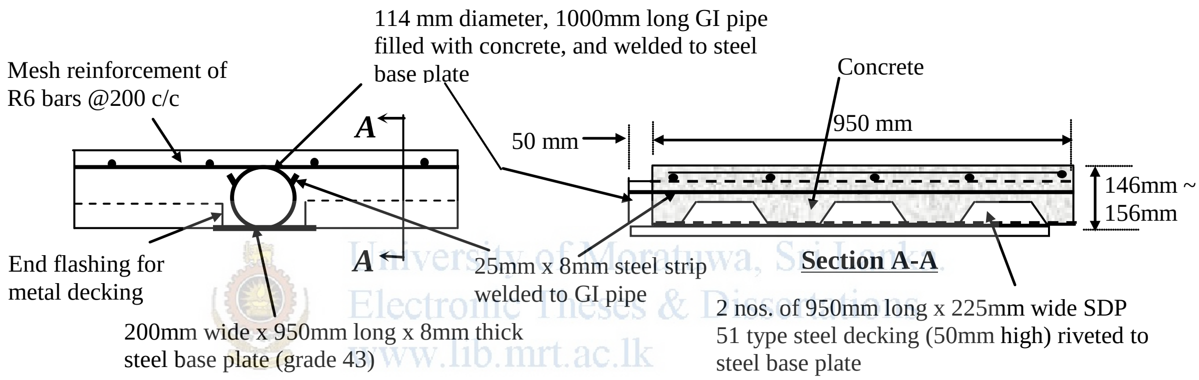
3.2.3 Configuration – 03

In this configuration conventional headed shear studs were used to improve the shear transfer capacity of composite slab.

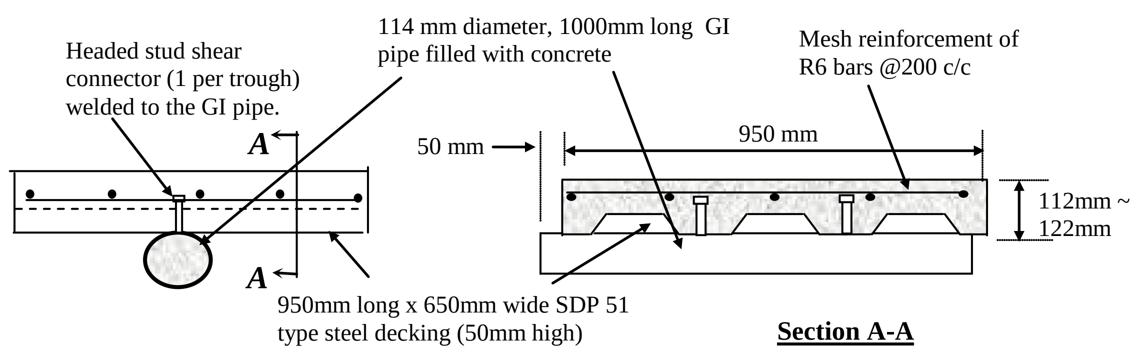
All push-out specimens were constructed similarly to the above two configuration. Steel tube and steel profiled sheet welded with headed shear studs before filling tube, as shown in Figure 3.1(c).



(a). Configuration 1

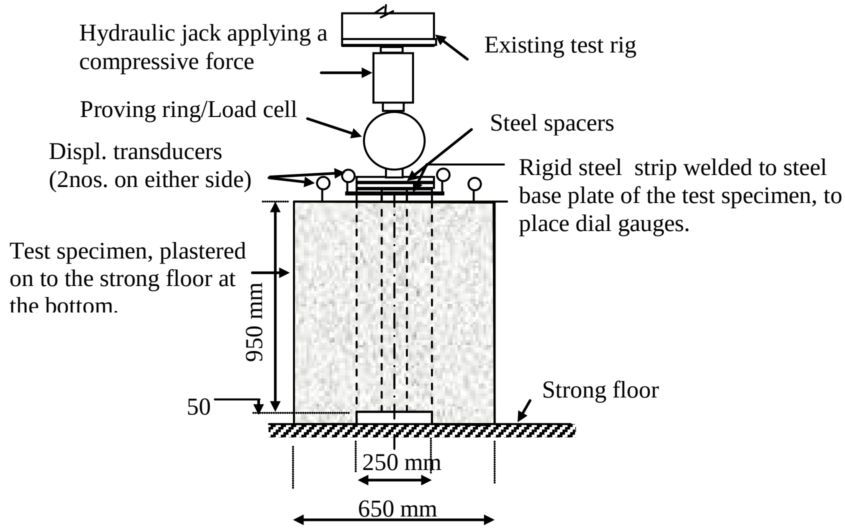


(b). Configuration 2

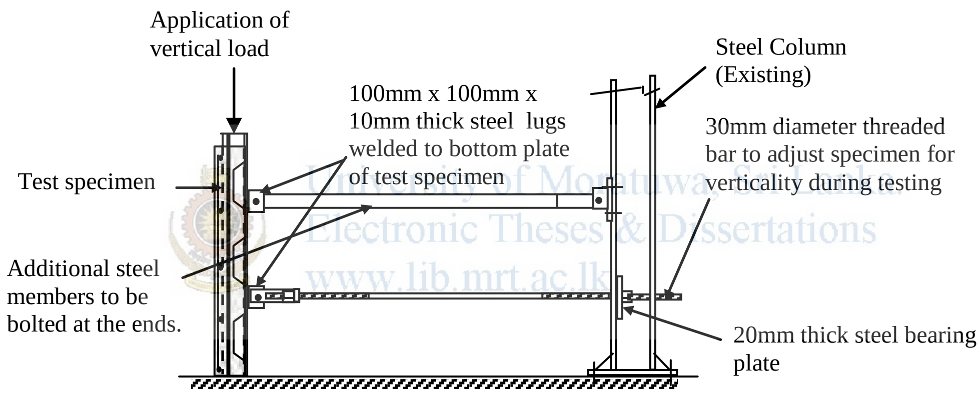


(c). Configuration 3

Figure 3.1: Different Configurations of Deck-Slab Specimens to be Tested.



(a). Elevation of the General Test Assembly.



(b). Side Elevation of Test

Figure 3.2: Test Arrangement

3.3 Materials

The materials used in the experimental programme were representative of actual composite slab construction and similar materials were used as much as possible in test samples.

The yield strength, the tensile strength and the maximum elongation of a representative sample of the shear connector, profiled steel sheeting, steel tube, steel plate, and flashings were determined.

3.3.1 Steel

The steel plates used with both configuration 1 and 2 (which is welded to steel tube) was 225mm width x 950mm length x 8mm thick hot rolled steel sections having a nominal grade of Fe 430, with a characteristic yield strength f_y of 275 N/mm^2 and an ultimate tensile strength f_u of 430 N/mm^2.

In the all series of tests, the reinforcement used for the transverse steel was square mesh fabric consisting of 6mm wires at a nominal pitch of 200mm. In all of the tests the transverse bars in the wire mesh were placed at the level of the shear connector heads, with cover of 20mm, 25mm, and 30mm. For both configurations 1 and 2 steel tubes were used as shear connectors, and for configuration 3 headed shear studs (grade of Fe 430) were used.

3.3.2 Concrete

The concrete mixes used in the programme were grade 20, 30, and 45. For each CFST four test cubes were checked with out curing. With each composite slab test sample four cubes were cast to check the compressive strength. On the composite slab testing day other test samples also tested. The maximum aggregate size used was 20mm and with each batch, slump was measured.

After concreting all composite slab samples curing was done for 7 days. For configuration 1 and 2 slab thickness varied 146mm-156mm. For configuration3 it was 112mm-122mm. The slab thickness variation was due to different concrete top cover.

3.3.3 Welding of the Shear Connectors

For both configurations 1 and 2 steel tube was welded to steel plate and two steel strips were welded to steel tube only in configuration2. The finished items were then visually inspected for any weld imperfection or incompletion, and were "ring" tested by tapping lightly with a small hammer.

Prior to commencing any stud welding on the push-out test specimens, two test studs were welded. These studs were bent to an angle of 30^0 from the vertical in the direction of the applied longitudinal load, using hammer. If any failure occurred in the weld zone, the welding procedure was adjusted and the test repeated. Once satisfactory weld collar were achieved, the shear stud were welded to the steel tube in both "weak positioning" and "strong positioning", accordingly. The finished studs were then visually inspected for any weld imperfection or incompletion, and were "ring" tested by tapping lightly with a small hammer.

3.4 Testing and Instrumentation

3.4.1 Testing Procedure

The load was first applied in increments up to 40% of the expected failure load and then cycled 25 times between 5% and 40% of expected failure load. Subsequent load increments were then imposed such that failure did not occur in less than 15 minutes. The longitudinal slip between each concrete slab and concrete filled steel tube was measured continuously during loading or at each load increment. As close as possible to each group of connectors, the transverse separation between the steel section and each slab was measured.

3.4.2 Instrumentation

3.4.2.1 Dial Gauges

In each test three 0.01mm-50mm dial gauges were positioned in the arrangement indicated in Figure 3.2. At each load increment dial gauges were used to monitor the relative longitudinal slip to the nearest 0.01mm.

In both configurations 1 and 2 sprit level and special apparatus were used to maintain verticality of the specimen as shown in Figure 3.2(b). But with configuration 3 another two dial gauges were used to measure transverse separation between the concrete and the steel section.