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Behaviour of RCC pedestals under Uniaxial Loads

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Abstract: *At the point when enormous concentrated burdens are acting over restricted territory of cement, the bearing quality of cement is known to be expanding because of the keeping weight of the wrapping concrete in the environmental factors of the contact zone. Simultaneously, the high contact weight might be many overlay of the compressive quality of the solid. There are loads of models in building uses of better usage of bearing limit, for example, steel base plates of steel sections and brackets over platforms, safe havens in post-tensioned pre-focused on solid pillars, bars at direction and supports, heap head and topping chunk, solid pivots, rockers, underpins for colossal road light structures and so on. Present examination focuses essentially on the impact of the geometry of the platform on the bearing quality of Reinforced concrete solid platform under concentric and uniaxial stacking conditions. Likewise, the impact of twisting and split examples are researched. RC platforms of various cross-area are considered in the investigation.*
Key words: *concrete Hinges; Pedestals; capping slab.*

I. Introduction

The bearing strength of plain and reinforced cement concrete, when subjected to concentrated loads has got as much importance as the compressive strength in concrete technology. When large forces are acting on limited contact area, high local contact pressure can be expected as the loading area is small. The application of this large forces in limited area occur in general engineering activities such as steel base plates of steel columns over concrete footings, anchorages in post tensioned prestressed beams , concrete beams at bearings and supports , pile head and capping slab , concrete hinges , base plates of trusses over concrete columns , rockers , supports for huge street light structures etc. The study of concentrated load acting over limited area and bearing strength of concrete has received considerable attention from the early 1970's. Tung, et.al. (1976) reported the results of an investigation on the bearing capacity of PCC blocks loaded through relatively larger base plates.

In the above study, two types of specimens of 200mm cube and 200x200x100mm block were used. Single type of loading was applied for each specimen. Based on the study, they reported that using 200mm cube specimen, the failure was by a vertical crack developed at the top of the block and then progressed downward, indicating splitting due to sliding failure. An inverted pyramid shape of concrete was punched into the block indicating tension failure. The smaller size block split radially and no clear-cut pyramid shape under bearing plate was observed. Cracks first appeared at the bottom of the sides and then progressed upward which indicated that splitting was caused by radial pressure resulting from large deformation of concrete under base plate.

Hawkins et.al. (1988) studied the behavior of PCC blocks with varying strength of concrete. Thus, he obtains various results according to the type and strength of concrete. He also found that square specimens with different area also differ in results and strength. Also concluded larger the area of the square specimen, larger will be the bearing strength. Combining both the works regarding the surface area of the specimen and the different types of concrete used, he mentioned as a scope to this about the geometry of the specimen also affects the strength in so many ways even though square specimens are preferred

Kamiswara et.al. (1991) presented the effects of fibre volume fraction and the ratio of unloaded to loaded area on the ultimate bearing capacity of concrete when loaded with concentric and eccentric loading using bearing plates. The main parameters of the study were volume fraction of the fiber, ratio of unloaded to loaded area, and type of loading concentric or eccentric. PCC blocks at failure developed fine vertical cracks on sides followed by formation of wedge of concrete under bearing plates. It was conical for circular plates and pyramidal for square bearing plates and the failure was sudden. In case of fibrous specimen, movement of plate into the specimen was considerable even beyond the ultimate loads indicating inherent ductility of fibre reinforced concrete. It was concluded that the failure of FRC specimen was not sudden and specimen were not splitted into parts, showing good ductility. Bearing capacity was lower for edge loading and it increases with increase in the ratio of unloaded to loaded area. Based on the experimental study, Tarig et.al. (1998) presented a detailed work on the bearing capacity of concrete blocks. Effect of block size on bearing capacity was also studied in detail. From the study it is concluded that when the percentage of lateral steel increases, the ultimate bearing strength also increases due to the effective spreading of concentrated load over the specimen. Bearing capacity decreases with the increase in eccentricity of the bearing plate. Failure of all the specimens was of tensile nature.

Jing et.al. (2002) studied the strength of RC pedestals loaded in concentric, eccentric and biaxial compression by varying the form of lateral ties, and geometry of loading and compared with PCC specimens. The study concluded that the longitudinal steel is at yield at the spalling load, while the lateral steel is not yielded at cover spalling load.

II. Experimental Investigation

2.1. Materials and Mix Proportion

Ordinary Portland cement confirming to IS 12269-1987 was used for the preparation of mixes, control specimen and test specimens. Laboratory tests were conducted on cement to determine standard consistency, initial and final setting time and compressive strength of cement. River sand passing through 4.75mm IS sieve; conforming to zone II available in the local market is brought for the experiments. Preliminary material testing procedures to determine the physical properties of the fine aggregate as per IS 383 (Part III): 1970 are conducted. Crushed granite of nominal 20mm size available in the local market is made use for the experiments. It was proposed to prepare a mix of M25 grade for casting the specimens in accordance with recommended guidelines in Indian standards (IS 1062-1982). The basic assumption made in the Indian standard method for mix design is that the compressive strength of workable concrete is by water-cement ratio. As per the IS design for the mix, the water cement ratio is 0.45. Standard cube specimens were prepared to check the compressive strength of 7th day ,14th day and 28th day. Thus the mix decided for the preparation of pedestals is 1:1:2 with water cement ratio of 0.45.

2.2. Details of Pedestal Specimens

The specimens with cross section 200x200mm were cast with two L/d ratios of 1.75 and 1.0 with heights 350mm and 200mm respectively. In each L/d ratio, uniaxial eccentric loading was selected. All of them were reinforced with 4 corner vertical bars of 12mm diameter and conventional type lateral ties of 6mm size. The clear cover to the vertical bars was maintained at 40mm. The specimens were cast in a mould set made of 20mm thick plywood. After 24 hours of casting the specimen were taken out and immersed in water tank for 28 days of

Figure 1 Rectangular Mould **Figure 2** Square Mould

In each ratios of L/d, the specimens are categorized mainly into two groups according to the eccentricity of loading especially uniaxial loading condition. Square shaped mild steel plates of 12mm thickness cut to desired dimensions according to the selected areas of bearing plates were used as base plates of loading. Pedestals subjected to uniaxial loading with an eccentricity of 50mm includes the categories like pedestals with bearing ratios of 0.25, 0.125, 0.0625.

III. Test Methods

The pedestals were tested in compression testing machine of capacity 300T. All the pedestals were placed directly on the steel base of the machine. The pedestals were loaded through square shaped steel bearing plates of varying areas according to the ratio of bearing area to block area. The pedestals were placed on the machine so that the area of loading that is, the bearing plate provided at the top comes centrally to the top ram of the machine. Usually demec gauge of 200mm length was used for measuring the longitudinal strain of the testing pedestal for each load increment. But as the square pedestal is of 200mm height, the 200mm length deemed gauge cannot be fixed. Therefore, dial gauges are positioned on the moving platform of the machine to measure the total deflection at each load increment and then the deflection divided by the original length of the pedestal gives the strain for each increment of the load. Thus, the strain and deflection can be calculated from these observations. After 28 days of curing in water tank, the pedestals were taken out from tank carefully and dried in air. Then they were white washed before testing for easy detection of cracks. The pedestals were placed over the lower platform of the machine and the dial gauge is fixed between the platform and the rigid frame of the machine. The bearing plate is placed over the pedestal exactly after making its position. Thin layer of lime was used for getting a smooth contact surface between bearing plate and the pedestal. After lowering and touching the upper ram over the pedestal, the initial readings of the gauges were noted. Loading started gradually and stopped at regular intervals and all readings were noted at each load increment until the pedestal fails. For each pedestal, the load at which the first crack occurs, progress of cracks, mode of failure and the ultimate load were noted.

Figure 3 Test setup Square specimen

Figure 4 Test setup rectangular specimen

IV. Results And Discussions

The main objective of the present investigation was to study the behaviour of concrete pedestals loaded over limited area. The parameters considered in the study are the geometry of the specimen, mode of failure etc. Uniaxial eccentric loading for ratios 0.25, 0.125 and 0.0625 with 50mm eccentricity. The bearing stress is calculated by dividing the corresponding load by the area of bearing plate and the base stress is calculated by dividing the load by specimen area that is 200x200mm.

4.1. Rectangular Pedestals with L/D Ratio 1.75

4.1.1. 200mm x 200mm cross-section pedestal with bearing ratio 0.25

The pedestal tested in this category is having a bearing ratio equal to 0.25 and loaded with an eccentricity of 50mm about one axis and symmetric about the other. While loading gradually, the first crack appeared on the inner corner of the bearing plate and started developing downward. Multiple randomly distributed cracks where then found on the front side of the plate and on the two sides. The cracking stress in bearing is lower than that of the specimen A04. There is very narrow difference between the bearing stress at cracking and the ultimate loads. This may be due to the lack of resistance offered by the reinforcements. The rear side of the specimen remained with no cracks. All the strains are compressive and the compressive strain on the bearing side is more than that on the rear face of the specimen. The deformation of the specimen at the cracking stress is 1.1152mm.

4.1.2. 200mm x 200mm cross-section pedestal with bearing ratio 0.125

The bearing plate used for this pedestal is having a bearing ratio of 0.125 at an eccentricity 50mm about one axis and symmetric about the other. While the loading on progress, the first crack started on front corner of the bearing plate and started developing downward at the bearing stress which is lower than the concentrically loaded pedestal of same area of bearing ratio 0.25. Subsequently cracks emerged from all the four corners and developed downwards. The portion of the specimen in front of the bearing plate separated out at the ultimate load. The failed pedestal has cracks on three sides. The confinement area of this specimen is more and steel takes part in resisting the load after the failure of confined concrete. The axial deformation obtained for the pedestal at cracking is 1.1080mm.

4.1.3. 200mm x 200mm cross-section pedestal with bearing ratio 0.0625

The pedestal was loaded through a base plate with bearing ratio 0.0625 with uniaxial eccentricity of 50mm. The first crack started from one of the front corners of bearing plate and progressed downwards. The cracks were not reaching the base and new cracks formed. The cracking stress observed is slightly lower than that of the pedestal with bearing ratio 0.0625 loaded concentrically. The top portion of the pedestal split like as a wedge. The top portion of the pedestal split like as a wedge. The three sides rendered cracks and the rear side remained without cracks. Here the ultimate bearing stress do not have much variation with respect to the cracking stress on bearing. The bearing side surface was more compressive in nature which failed at ultimate load. The axial deformation obtained for the pedestal at cracking is 1.1100mm.

4.2. Square Pedestals with L/D Ratio 1.0

4.2.1. 200mm x 200mm cross-section pedestal with bearing ratio 0.25

The testing of this pedestal was done through base plate provided with eccentricity of 50mm about one axis. On progress of loading, the first crack started from the middle of bearing plate that is on face three, started moving vertical and then propagated diagonally. Simultaneously, a few more cracks started developing on face 2 and 4 generating vertically and then progressing diagonally. The face 1 remained without cracks and at the ultimate failure; vertical cracks near the edges are formed. The bearing stress at the first crack is lower than the similar pedestal having L/d ratio 1.75. The deformation of the centroid of base plate measured at the cracking load was 0.255mm. The strain values measured in the pedestal at the mid height vary slightly according to the distance from the point of loading.

4.2.2. 200mm x 200mm cross-section pedestal with bearing ratio 0.125

The first crack started from the edges of the bearing plate, extended to face three, started moving vertical and then propagated diagonally. Radial cracks generated at the rear corners of the base plate, continued to face 2 and face 4 then moved vertically downward. Horizontal cracks are also seen in face 2 and 4 at the ultimate failure. Face 1 remained with no cracks. The front portion of the specimen near the base plate was split from it at the ultimate failure. The observed bearing stress at the first crack was lower than the similar pedestal having L/d ratio 1.75. The deformation of the centroid of base plate measured at the cracking load was 0.240mm. The strain values measured in the specimen at the mid height vary slightly according to the distance from the point of loading.

4.2.3. 200mm x 200mm cross-section pedestal with bearing ratio 0.0625

Majority of the cracks were generated from the front edges of the bearing plate having lesser concrete thickness in front, then extended to face three, and then to face 2 and 4. On face 3, the vertical cracks generated and continued up to mod height and then proceeded diagonally. The cracks from corner of bearing plate continued in vertical direction in face 2 and face 4 and the front portion of the pedestal separated out at ultimate failure. There were no cracks identified at face 1. The bearing stress at the first crack was very much lower than the similar pedestal having L/d ratio 1.75. The deformation of the centroid of the base plate measured at the cracking load was 0.232mm.

4.3. Comparison with Rectangular Plate on Square Pedestal

The study of square shaped bearing plate on square cross-section pedestal and its bearing strength with respective parameters are done in previous chapters. Here for the comparison, the effect of bearing capacity of the square pedestal when rectangular plate is placed over, which is also done. As the study progressed, multiple cracks formed at the bottom immediately and it is found out that the specimen failed at a load of 20T with a deformation of 0.205mm. Thus, it is the lowest load carrying capacity than the square specimen with square bearing plate. So, it can be concluded that a square bearing plate on a square pedestal is having greater bearing strength than the square pedestal with rectangular bearing plate.

Table 1 Bearing Stress

Pedestal with 200x200mm cross section	**Bearing stress at cracking**	**Ratio with control**	**Bearing stress at ultimate load**	**Ratio ultimate/crc**	**Cracking load(T)**
Uniaxial load L/d ratio=1.75					
Bearing ratio 0.25	36.45	1.52	40.47	1.13	36.45
Bearing ratio .125	60	2.5	72.38	1.23	30

Bearing ratio 0.0625	120	5	134.3	1.02	40
Uniaxial L/d=1					
Bearing ratio 0.25	34	1.98	44	1.53	322
Bearing ratio .125	52	3.4	68	1.983	26
Bearing ratio 0.0625	76	4.63	87	1.22	18

V. Conclusions

The bearing strength of reinforced cement concrete pedestals loaded over limited area was studied in detail. The effect of the ratio of bearing area to block area on the bearing strength in uniaxial eccentric loading was analyzed and discussed. The parameters such as eccentricity, L/d ratio, deformation and failure characteristics are also studied. The bearing strength of rectangular pedestal is more than that of the square pedestal. By the reduction of bearing area from full area to 1/16th of block area, the bearing stress at failure is found to be increasing in concentric and eccentric cases of loading. On a particular bearing area, the failure load as well as the bearing strength decreases with the change in loading. The crack pattern in higher bearing ratios are different from lower ratios of bearing. Noticeable variation observed between the bearing stress at first crack and ultimate stress in higher ratios of bearing. The bearing strength of the pedestals decrease with the reduction in length of the specimen.

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