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# Experimental Investigation of Unreinforced and Reinforced Masonry Slab

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## Abstract

Unreinforced Brick masonry is a non-homogeneous material made of bricks as the building units and the mortar as the interface material. Brick masonry has a high compressive strength under vertical loads but has a low tensile strength against bending. Reinforced brick masonry show greater resistance against shear and bending. Brick masonry slab have good appearance, fire resistance capacity, thermal and acoustics performance, free from corrosion of reinforcement etc. Two types of masonry slab with herring bone bond pattern were fabricated using wire mesh and minimum reinforcement in addition to that one traditional RCC slab was also fabricated using minimum reinforcement. The masonry slabs failed due to brick failure without any advance warning. The crack pattern of masonry slabs using wire mesh and minimum reinforcement were flexure-tension and web-shear respectively. The crack pattern of RCC slab was flexure-shear. The maximum flexural stress carried by RCC slab, masonry slabs with wire mesh, with minimum reinforcement were 488 psi, 194 psi and 387 psi respectively where the maximum deflections were 0.157 inch (3.98 mm), 0.083 inch (2.1 mm) and 0.05 inch(1.28 mm), respectively. Reduction of cost of masonry slabs using wire mesh and minimum reinforcement from RCC slab are 24.14

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***Index terms—***

# 1 Introduction rick masonry is one of the oldest forms of building construction

Brickwork is a composite material with bricks as the building units and the mortar as the jointing material (Freeda Christy C. et. al, 2013).The strength of the bricks-work primarily depends upon quality and strength of the brick, the type of mortar and the method of bonding adopted in construction, type of material used, nature of workmanship and supervision. Brick masonry plays a significant role in the construction industries of bangladesh where natural stones are not available and other type of building materials like concrete, MS sheets or CI sheets, and artificial materials are costly. The rapid progress over recent past in the understanding of the materials and considerable advances in the method of design have increased acceptance of load bearing masonry as a variable structural material. (S.P. Bindra, 2013). In residential buildings, roof system is a vital part.

The selection of the type of material and construction is made, keeping in view the requirements of strength, water proofing, thermal insulation, fire resistance, durability and economy. It was therefore felt to investigate the local carrying capacity of different type of masonry slab. Reinforced brickwork is a typical type of construction in which the compressive strength of bricks is utilized to bear the compressive stress and steel bars are used to bear the tensile stresses in a slab. In other words the usual cement concrete is replaced by the bricks. However since the size of a brick is limited, continuously in the slab is obtained by filling the joints between the bricks by cement mortar. The reinforcing bars are embedded in the gap between the bricks which is filled with cement mortar. The designs of reinforced bricks slab are similar to these of reinforced concrete slab. (B.C. Punmia, 2012).Ahmed, T.

and Junayet, A., ??1996) carried out a comparison study between Ferro cement slab and conventional R.C.C. slab in terms of their flexure behavior and cost. In terms of appearance, durability and cost, brick masonry is comparatively superior to other alternatives ??Hossain, M. M. et al., 1997). The main aim of this study is to investigate the mechanical properties of masonry slabreinforced with alternative materials (wire mesh and minimum reinforcement) to evaluate their performance and economy compared to conventional RCC slab. An endeavor will make to evaluate the feasibility of masonry slab to replace RCC slab.

# 2 II.

# 3 Materials and Methods

# 4 a) Specification of Materials

In this study Bricks, Portland Composite Cement, Sand and Reinforcement (wire mesh and deformed bar) from the local manufactures has been used and the properties of brick and mortarare given in Table 1 From table 1, it is found that the AKIJ brand brick have maximum compressive strength. The water absorption capacity is 12.22 % which is less than 1/6 of it's own weight. AKIJ brand brick was uniform in color, size and shape is regular, campact, free from crack and other flaws such as air, bubbles, stone nodules etc. Although it's cost is maximum but don't vary too much from the other brand. So AKIJ brand brick was selected for the final work. Bashundhara cement with Khustia sand having fineness modulous of 1.65 in ratio 1:2 gives greater compressive strength. So it was selected for the final work.

# 5 b) selection of slab

Two types of masonry slab reiforeced with wire mesh and minimum reinforcement and one traditional RCC slab having dimension 4ft x 2.5ft x 4.5 inch were selected for the test.

# 6 c) Design of Masonry and Rcc Slab

The slabs were designed as one way slab. In case of masonry slab reinforced with wire mesh 0.5 inch spacing wire mesh was used. The bottom clear cover was 0.75 inch and top mortar layer was 0.5 inch.

In masonry slab using minimum reinforcement 10 mm dia bar was used. The number of reinforcement in long direction was 5 nos and in short direction was 7 nos. Reinforcement was used only in tension zone. No shear reinforcement was used. Bottom clear cover was 0.75 inch and top mortar layer was 0.5 inch.

In traditional RCC slab the number of reinforcement was kept as same as masonry slab using minimum reinforcement so that they can be compare in a similar way. Bottom clear cover was 0.75 inch.

Herring bone bond pattern was used in masonry slabs. The contribution of brick in slabs thickness was 2.75 inch. In this arrangement of brick work, bricks are laid above bottom surface inclined at 45 0 in two directions from the center. Cross-section of the above mentioned slabs are shown in figure ??(a), figure ?? The load was applied by the hydraulic jack by pumping it. The reading of deflection gauge at each point was taken with respect to each small division of pressure gauge. The data were recorded untill the failure of slab.

# 7 III.

# 8 Results and Discussion

a) Masonry slab using Wire mesh In masonry slab using wire mesh no deformed bar was provided. After curing for 28 days the slabs failed under load and the loads are shown in table 3. Deflection was measured at 3 points as remarked in the typical experimental setup. The masonry slab using wire mesh was found to take 9.1 kips load before failure which is equivalent to 1000 psf load. Maximum deflection is 2.1 mm at mid point. Deformed bar were used in masonry slab using minimum reinforcement. The masonry slab using minimum reinforcement carried 20 kips load before failure which is equivalent to 2000psfload. Maximum deflection was found 1.28 mm at point 2. RCC slab using minimum reinforcement took 22.59 kips load before failure which is equivalent to 2500 psf load. Maximum deflection is 3.98 mm. Figure 3 shows the variation of deflection with load for all types of slab at point 1 which is located at a distance 17 inch away from the right support. The deflection at point 1 is maximum for RCC slab, second maximum deflection was found for masonry slab using wire mesh. This is due to the elasticity of the wire mesh. Masonry slab using minimum reinforcement shows minimum deflection due to use of deformed bar and brittleness of brick. Figure ?? shows the variation of deflection with load for all types of slab at point 3 which is located at a distance 17 inch away from the left support. The minimum deflection is for masonry slab using minimum reinforcement and maximum deflection is for RCC slab. Masonry slabs failed suddenly without any advanced warning due to the brittleness of brick. There is no yield point in the figures which ensure the sudden failure of slabs.

# 9 b) Masonry slab using minimum reinforcement

# 10 c) RCC slab using minimum reinforcement

# 11 IV. Variation of Deflection at Points

# 12 V.

Crack Pattern a) Masonry slab using wire mesh Figure **??** : Failure pattern of masonry slab using wire mesh

The failure pattern of masonry slab using wire mesh is flexure-tension type. Failure occurred at almost midpoint. This type of failure may be initiated due to the increase of principle tensile stress greater than combined tensile stress of brick and mortar. The failure was sudden due to the brittleness of brick and the deflection was greater than masonry slab using minimum steel due to the greater elastic property of wire mesh. The crack of RCC slab using minimum steel initiated due to the flexure but the failure occurred due to the combined action of flexure and shear. This type of failure occurred due to the increase of combined flexure and shear stress greater than principle tensile stress of concrete.

# 13 b) Masonry slab using minimum reinforcement

# 14 VI.

# 15 Economy Analysis

The amount of materials required in the manufacture process and the cost of three types of slab is shown in table 6 and table 7 Deviation of load carring capacity of masonry slabs using wire mesh and minimum reinforcement from RCC slab are 60.11% and 11.46% respectively; deflections are 47.24% and 67.84% respectively; flexural stresses are 60.25% and 20.70% respectively and costs are 24.14% and 2.85% respectively. The deviation of performance and costs of masonry slabs from RCC slab in shown in the following bar diagrams. ? Deviation of load carring capacity of masonry slabs using wire mesh and minimum reinforcement from RCC slab are 60.11% and 11.46% respectively; deflections are 47.24% and 67.84% respectively; costs are 24.14% and 2.85% respectively. ? Masonry slabs failed due to brick failure without any advanced warning. The crack pattern of RCC slab, masonry slab using wire mesh and minimum reinforcment are flexure-shear, flexure-tension and flexure-shear respectively.

? Masonry slab using wire mesh can be used in case of small span slab, restricted roof and waffle slab system. For long span slab and higher tension, masonry slab using minimum steel or RCC slab can be used. As the cost of RCC slab is only 2.85% greater than the masonry slab using minimum steel, so RCC slab is preferable for higher tension. But in case of architectural appearance and deflection restriction, masonry slab using wire mesh can be used. [1] [2]

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Figure 1:

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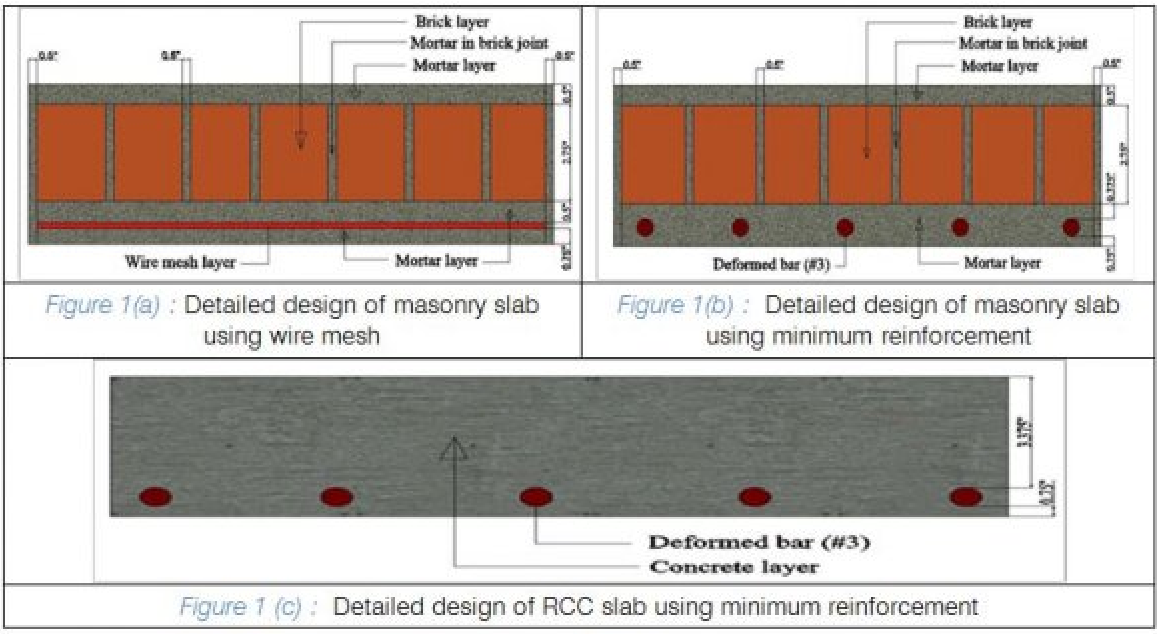



Figure 2: Figure 2 (

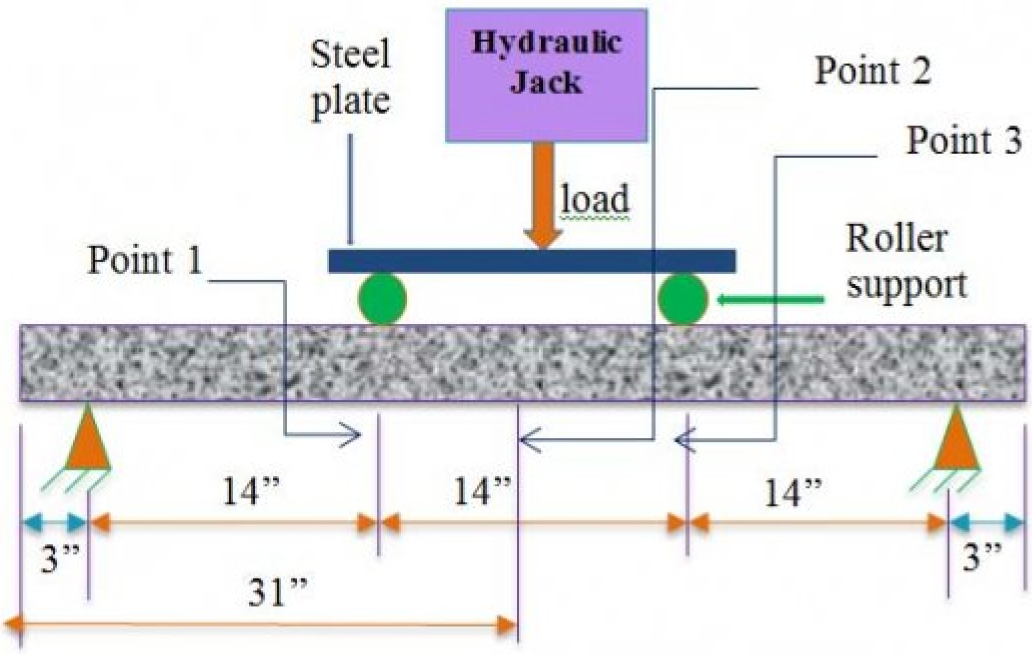
2 


Figure 3: Figure 2 (

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Figure 4: Figure 3 :

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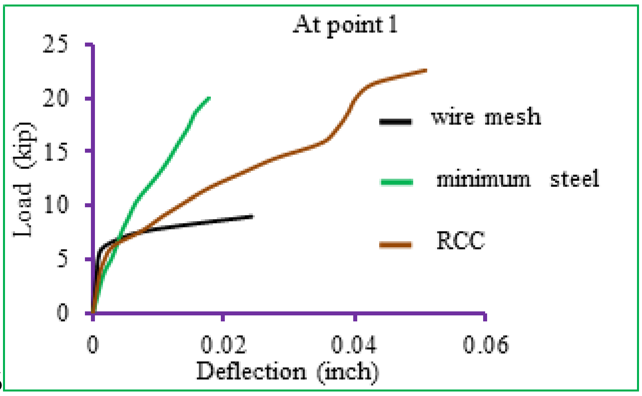


Figure 5: Figure 4 : 2 Figure 4 Figure 5 :

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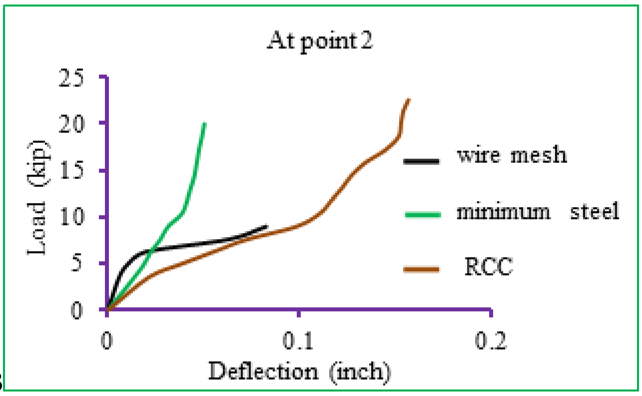


Figure 6: ExperimentalFigure 7 :Figure 8 :

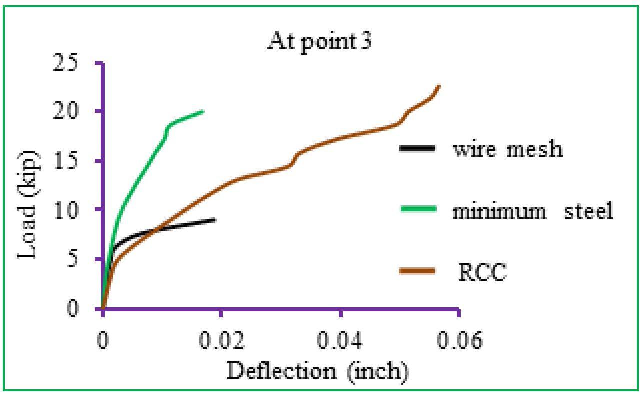


Figure 7: ?

Figure 8:

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Figure 9: Table 1 :

**2**

| Age | Ratio (1:2) | Average Compressive Strength (psi) |
|---|---|---|
| | Cement : Kushtia Sand | 2950 |
| 3 days | Cement : Sylhet Sand | 3125 |
| | Cement : Sylhet + Kushtia Sand | 3045 |
| | Cement : Kushtia Sand | 3790 |
| 7 days | Cement : Sylhet Sand | 3750 |
| | Cement : Sylhet + Kushtia Sand | 3630 |

Figure 10: Table 2 :

**3**

| Observed Pressure gauge Value | Load (kN) | Load (kip) | At Point1 Deflection (mm) (in) | | At Point 2 Deflection (mm) (in) | | At Point 3 D |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 15.8 | 3.55 | 0.015 | 0.00059 | 0.15 | 0.0059055 | 0.021 |
| 2 | 22 | 4.94 | 0.019 | 0.00074 | 0.265 | 0.0104331 | 0.034 |
| 3 | 28 | 6.29 | 0.048 | 0.00188 | 0.5 | 0.019685 | 0.055 |
| 4 | 34 | 7.64 | 0.2 | 0.00787 | 1.6 | 0.0629921 | 0.168 |
| 5 | 40.1 | 9.01 | 0.617 | 0.02429 | 2.1 | 0.0826772 | 0.475 |

Figure 11: Table 3 :

**4**

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Figure 12: Table 4 :

**5**

| Observed Pressure gauge Value | Load (kN) | Load (kip) | At Point1 Deflection | | At Point 2 Deflection | | At Point 3 Deflection | |
|---|---|---|---|---|---|---|---|---|
| | | | (mm) | (in) | (mm) | (in) | (mm) | (in) |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 15.8 | 3.55 | 0.03 | 0.00098 | 0.54 | 0.02125 | 0.037 | 0.00145 |
| 2 | 22 | 4.94 | 0.04 | 0.00173 | 0.96 | 0.03779 | 0.063 | 0.00248 |
| 3 | 28 | 6.29 | 0.08 | 0.00314 | 1.4 | 0.05511 | 0.125 | 0.00492 |
| 4 | 34 | 7.64 | 0.19 | 0.00740 | 1.85 | 0.07283 | 0.205 | 0.00807 |
| 5 | 40.1 | 9.01 | 0.27 | 0.01062 | 2.5 | 0.09842 | 0.29 | 0.01141 |
| 6 | 46.1 | 10.36 | 0.36 | 0.01417 | 2.8 | 0.11023 | 0.372 | 0.01464 |
| 7 | 52.25 | 11.74 | 0.46 | 0.01811 | 2.95 | 0.11614 | 0.465 | 0.01830 |
| 8 | 58.45 | 13.14 | 0.59 | 0.02322 | 3.1 | 0.12204 | 0.58 | 0.02283 |
| 9 | 64.15 | 14.42 | 0.71 | 0.02803 | 3.22 | 0.12677 | 0.79 | 0.03110 |
| 10 | 70.25 | 15.79 | 0.89 | 0.03484 | 3.4 | 0.13385 | 0.84 | 0.03307 |
| 11 | 76.7 | 17.24 | 0.95 | 0.03740 | 3.68 | 0.144881 | 1.005 | 0.03956 |
| 12 | 83 | 18.65 | 0.99 | 0.03897 | 3.85 | 0.15157 | 1.25 | 0.04921 |
| 13 | 89 | 20.00 | 1.02 | 0.04015 | 3.88 | 0.15275 | 1.305 | 0.05137 |
| 14 | 95 | 21.35 | 1.09 | 0.04291 | 3.91 | 0.15393 | 1.398 | 0.05503 |
| 15 | 100.5 | 22.59 | 1.29 | 0.05078 | 3.98 | 0.15669 | 1.435 | 0.05649 |

Figure 13: Table 5 :

**6**

| specifications | Masonry slab with wire mesh | with minimum reinforcement | RCC |
|---|---|---|---|
| Cement (kg) | 17 | 19 | 19 |
| Fine Aggregate [1] (cft) | 0.924 | 1.06 | 1.2 |
| Fine Aggregate [2] (cft) | 0.013 | 0.013 | - |
| Coarse Aggregate (cft) | - | - | 1.8 |
| Steel (kg) | - | 6.5 | 6.5 |
| Brick (nos) | 31 | 31 | - |
| Wire mesh(sft) | 7.9 | - | - |
| Brick work (cft) | 2.29 | 2.29 | 0 |
| Casting (cft) | 0 | 0 | 3.75 |
| Plastering (sft) | 10 | 10 | 0 |
| Fabrication of steel (kg) | 2 | 6.5 | 6.5 |

Figure 14: Table 6 :

**7**

| specifications | unit cost (tk) | Cost (tk) with wire mesh | With minimum reinforcement | RCC slab |
|---|---|---|---|---|
| Cement (kg) | 8.3 | 141.1 | 157.7 | 157.7 |
| Fine aggregate [1] (cft) | 60 | 55.44 | 63.6 | 73.2 |
| Fine aggregate [2] (cft) | 35 | 0.455 | 0.455 | 0 |
| Coarse aggregate (cft) | 160 | 0 | 0 | 292.8 |
| Steel (ft) | 55 | 0 | 357.5 | 357.5 |
| Brick (nos) | 8 | 248 | 248 | 0 |

*[Note: Experimental Investigation of Unreinforced and Reinforced Masonry Slab Global Journal of Researches in Engineering ( ) Volume XVI Issue II Version I VII. Deviation of Performance and Cost of Slabs]*

Figure 15: Table 7 :

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