Design and Development of Sustainable Wall

Abhay Khajuria, Sandeep Salhotra

Abstract: ***With the advancement in every sector at present time, construction sector is also witnessing major advancements. Construction is getting time saving, more eco friendly and reforming our lives in many ways. Green technology is the need of the hour and saving time is also very important. This paper is about constructing wall in such a way so that constructing wall is not only time saving and having good strength but also material efficient. To achieve this purpose instead of constructing wall at once it is divided into small pre-cast units for which hollow concrete blocks and steel bars are used. In this way construction of wall, can be made less time consuming along with better strength. One of the another major benefits is material can be re-used as steel bars will not make permanent bond with the blocks. This study is done to develop a method which can be applied anywhere, specially at those places where quick construction is required as in the case of disasters like floods, soil erosion etc.***

Index Terms: Disaster Management, Reusable Wall, Sustainable Wall, Quick Construction

I. INTRODUCTION

Everyday something new is being created in the world. With advancements, construction has been made fast, strength has been increased and made more eco friendly. This study also aims at fulfilling the same purpose. In this paper, wall is constructed in such a way so that it can be constructed quickly, fulfills the strength criteria and can be good for environment. To make it time saving, pre-cast members are used in this. To make a bond with each other, reinforcement bars are used. To fill the space left in the block around the steel bars is filled by aggregates. The aim to use this method is that using precast members will reduce the time of construction as the wait which needed to be done in case of conventional methods to gain full strength as in RCC or masonry, will be reduced. Along with that, some other benefits are also there like strength and as no member is making any permanent bond, so by just reassembling the blocks material can be used somewhere else also helps making it more Green method of construction. This will contribute towards environment in many ways. There is no need to demolish the structure when the need of wall is over as by reassembling wall could be removed, hence no brown field will be formed. But in conventional methods, by demolishing dumping of material was also a problem, thus eliminated by this method. Using precast members will not take much time to make wall usable. This can help during the time of disaster like floods, soil erosion etc. This wall can be constructed quickly and can secure the shores of surface and will save more damage in the affected areas. With the use of steel bars which are good in tension can make it more effective in the areas vulnerable to earthquakes as the pattern of damage done by seismic load is because of the failure of bond between the bricks.

This will also provide flexibility to people with the construction as making changes in structures will become more easy and cheaper than it is with conventional techniques. The type of material used and the pattern of preparing sample for that is explained further.

1.1 Materials

1.1.1 Hollow concrete blocks

Hollow concrete blocks were used for this study having dimensions 40 cm in length, 20 cm in width and 20 cm in height. The concrete mix used for this was M10. These were manufactured in a machine having mould. The concrete mix can be changed as per need.

Figure 1: Hollow Concrete Blocks

1.1.2 Steel Bars

Steel bars in L shape were used in this which were 16mm in diameter and of Fe500 grade. The length of each bar was 1m above the PCC base.

1.1.3 Bricks

Brick was used which is commonly used in India. It is second class brick with the compressive strength of approx 7 $kN/mm^{2.}$

1.1.4 Coarse aggregate

Coarse aggregate retaining on 4.75 mm sieve was used in PCC. Also it was used as a filler material in the space left in concrete blocks.

1.1.5 Water

Fresh water with no turbidity, no smell and with no visible impurities was used.

1.1.6 Cement

Ordinary Portland cement of 33 MPA grade was in this study.

1.2 Preparation of Wall Specimen

Revised Manuscript Received on July 05, 2019.

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1.2.1 Size of wall

The size of wall is 1m in height, 1.2m in length and 0.2m in width. The wall above ground level was 0.8m and 0.2m was below ground level. Reinforcement bars of 16mm were used which were 12 in number, 4 in each block.

1.2.2 Type of Foundation

PCC was done in foundation of M15 grade and 15cm in height. Reinforcement bars in L shape were used having 15cm length of bend given to make it L shaped. The reinforcement bars were laid from half the height of foundation.

1.2.3 Pattern of Laying of Concrete Blocks

Concrete blocks were laid in a way so that no block will come exactly over one block. Instead one block was resting over two blocks as shown in diagram. Four steel bars were taken through one block (one from each cavity in block). Also to fill the spaces between the blocks, sand and aggregates were used in dry state.

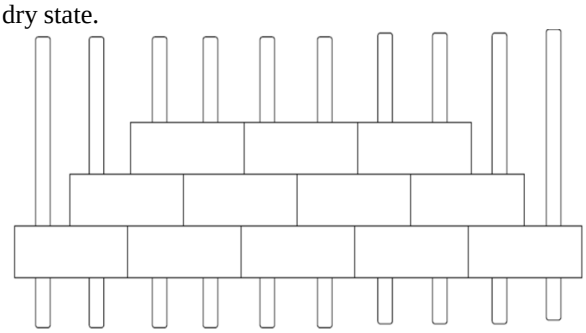

Figure 2 Pattern of laying concrete blocks

Figure 3: Sustainable Wall

1.3 Cost Comparison between Conventional Concrete Wall and Present Method

The material cost for constructing wall with present technique is approximately 1.5 times more than the conventional masonary wall. Following is the cost comparison between present study and hollow concrete blocks masonry of size 120cm*20cm*100cm. This analysis is done as per the rates which were available at the time of research.

Type	Cost of Concrete Blocks (Rs)	Cost of Reinforcement Bars (Rs)	Cost of Filler material (Rs)	Total (Rs)
Present Wall	750	700	70	1520
Concrete Hollow Block Masonry	750	0	170	920

Table no 1: Cost Comparison between Concrete masonry wall and present wall

But there is another side, this technique can save money in many other ways also. As it will provide more freedom to keep making changes in the structure, so it is human nature that one will try to make changes like changes its location, dimensions or even removing wall more often than if wall is constructed through conventional way.

If someone make changes, he will save cost for buying new material and its transportation. If wall is constructed through conventional way then it need to be demolished, so cleaning and dumping of material will cost something but this cost will be saved in this technique. Also as construction of this wall is faster than conventional way so it will again save money.

Also reusing material depends on the condition at which the wall is constructed. It should not be made for the load more than its capacity.

1.4 Expected Benefits

Constructing wall by this method can result in following benefits:

- Time of construction of wall will be reduced as pre-cast blocks are used.
- After the use of wall is over, the material of wall can be reused as there is no permanent contact between the blocks is made.
- It will have better lateral strength as reinforcement bars are used when compared with conventional concrete block wall .
- It will be effective against cracks as wall is divided into small sub parts.
- One damaged block will not effect other parts of wall and can be repaired easily by casting in situ.
- It will not convert land into brown fields.
- It will reduce the need of new dumping sites and will not effect environment.

2 Tests and Results

For testing a specimen was prepared at a site. For that steel bars with shape L were used in foundation which could help them to provide a strong base. Hydraulic jack was used to put load on the wall laterally. The specimen is tested for lateral strength in this research. As lateral strength is very important, as wall can perform well in the areas where it is needed for shoring purposes like during floods or to retain some load from falling on the other side.

Also it is tested for compressive strength. For this test, wall specimen was made and was tested on UTM.

2.1 Water Absorption test of concrete blocks & Brick

Concrete blocks and bricks were used in the construction of wall. Water absorption can play an important role in the durability of the construction material and in the wall constructed with this. For this, three kind of sample were tested i.e. empty concrete block, HB1, aggregate filled, HB2 and brick. First the blocks and brick were oven dried for 24 hours and then its weight was calculated. Then, the blocks and brick were kept in water

for 24 hours. Then after taking them out of water they were wiped with the help of a cloth and again its weight was calculated. The value for water absorption of brick is found higher than the HB1 and HB2. The values are written below:

Sample	Water Absorption percentage
HB1	6.25
HB2	5.51
Brick	14

Table no 2: Average Water Absorption test values

2.2 Compressive Strength Test of Concrete Blocks & Brick

The blocks were tested with the help of UTM. They were subjected under vertical load. This test value is important as wall is used as a compression member in almost every structure. It depends on the grade of concrete is used for this. The value was given by the manufacturer which was in between 7.5N/mm^2 – 10N/mm^2 as the blocks were manufactured with M10 grade, but to find the exact values this test was done on 3 samples named as HBC. Along with that brick were tested for compressive strength named as B1. The average values are written below:

Sample	Compressive Strength, N/mm^2
HBC	8.6
B1	7.3

Table no 3: Compressive Strength of Concrete Blocks

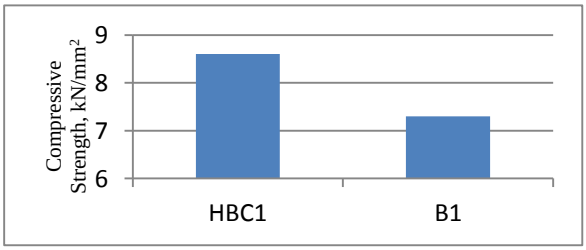

Figure 4: Graph showing the variation of compressive strength of concrete blocks

2.3 Flexural Test of Hollow Concrete blocks

In this test, concrete beam is bent until the time of failure. The flexural test of blocks was done on UTM. The test was done by bending block at 3 points. The observed value is written below:

Figure 5: Flexure Test of Concrete Block

Figure 6: Load vs. Displacement Graph

The average test values of concrete blocks and brick are given below:

Sample	Flexural Strength, kN/mm^2
Hollow Concrete Block	21
Brick	2.8

Table no 4: Flexural strength value of hollow concrete block and brick

2.4 Lateral Strength Test Results

It has been tested for lateral strength. Three samples were tested of same dimensions and with same design. After inserting load with the help of hydraulic jack, load value is taken at the time of cracking. The load was inserted from the back side of the wall specimen. For that a setup was created so that jack could be fixed at one place so that jack could not move to other side of where loading is required. This test becomes very important as this wall can be become a better option for shoring purposes and because of the use of steel bars it is expected to be used in earthquake prone regions. The average value of lateral load which is noted at the time of failure is 160 kN. **Here SB stands for sustainable wall, BW stands for brick wall and HCM hollow concrete block masonry**. Following are the result values for lateral strength test:

Test results and Graph

Sample	Cracking Load, kN
SB1	160
SB2	158
SB3	163
BW1	35
BW2	39
BW3	26

HCM1	54
HCM2	57
HCM3	64

Table 5: Test Results for Lateral Strength

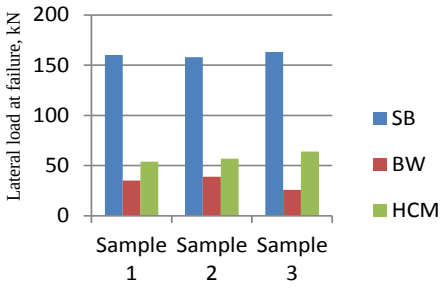

Fig: Graph showing the variations in the test results of three samples

2.5 Compressive Strength Test

Compressive strength is important to measure in a wall as in most of the cases wall is supposed to take the vertical load like in buildings. Compressive strength was found near the expected compressive strength of masonary wall which can be used in buildings and sometimes it is used in making boundary walls and factories. To test sample for compressive strength, sample was made and was put on UTM (Universal Testing Machine). The values were taken untill the time it got its first crack. For this test also, three samples were prepared in the same way as in the samples for lateral loading. Filler material was filled in the voids present in between the blocks and steel bars. Values were taken in kN. 552 kN is the average value for the compressive strength of the wall specimen. The results are in the following table.

Test results and graph

Sample	Cracking Load, kN
SB1	640
SB2	593
SB3	653
BW1	232
BW2	253
BW3	279
HCM1	521
HCM2	561
HCM3	548

Table 6: Test results for Compressive Strength

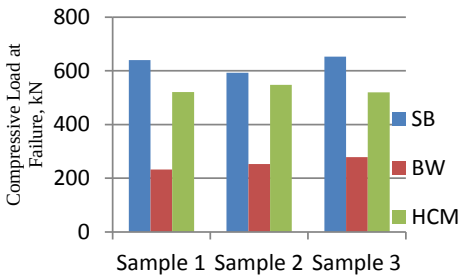

Fig: Graph showing variations in the test results of three samples

II. CONCLUSION

After investigating wall on different aspects following things have been concluded:

- Before testing wall for different strength, first it was tried to reassemble its parts. Reassembling was easily done so the main purpose of the study to make it sustainable was fulfilled.
- Its lateral strength and compressive strength was found reasonable as it can be required to fulfill the requirement at almost any place.
- The initial cost is found more but as it is sustainable, so it is going to save money in many other ways if material is tried to reuse.
- Construction is faster as it does not need many days to gain strength because of the use of pre cast material.
- Cracks occurred in the concrete blocks, so by changing the mix design strength can be increased.
- When compared with brick wall and hollow concrete block masonry, its value is found to better in every test.

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