Solid Concrete block Arch behaviour in Substructures

Ganesha Mogaveera[a], Vidyashree.M [b], Umesh S S[c]

[a] Professor & HOD , DeptiofiCivil Engg , MITE, Moodabidri , Karnataka , India
[b]Research Scholoar , DeptiofiCivil Engg, MITE, Moodabidri , Karnataka , India
[c]Associate Professor , DeptiofiCivil Engg , MITE, Moodabidri , Karnataka , India
[a]hodciv@mite.ac.in, [b]vidyadarshi25@gmail.com, [c] umesh@mite.ac.in

Article History: Received: 10 January 2021; Revised: 12 February 2021; Accepted: 27 March 2021; Published online: 28 April 2021

Abstract: Now a days the cost of construction is increasing due to increase in cost of materials. It is required to reduce by implementing the arch foundations using solid concrete blocks. The bending moment and shear acting over the cross-sectional area are significantly smaller contrasted with that of beams of same span and carrying the similar load. Using different materials arches can be constructed. This type of construction will save the materials cost and also improve the structural behavior of solid concrete block arches. Uniformly distributed load has been tried using loading frame. An impact of rise of arch on load carrying capacity has been studied. A cement mortar 1:6 proportions is used in the joints. First crack has been observed at the load of 17.658kN/m which is around 80% of ultimate load. Hence this type of foundations can be recommended upto two storied buildings

Keywords: Arch, Masonry, Solid Concrete blocks, Loading frame, Deflection, Transducers.

1. Introduction

An arch is a structure which is constructed to span across an opening such as a river, valley or bridging across a railway lines etc. In case of building components such as doors, windows, ventilators etc., Beam normal carries higher shear force and bending moment in comparison with arches of similar span and carrying the equal load. Arches are known since past times and have been utilized widely for the development in the field of constructions specially bridges. For the construction of various types of bridges. Strength and durability of such type of structures are magnificent high. As a roofing element also now a days the brick masonry arched panels have been utilized to keep away from the use of expensive materials like steel and concrete. Arches are notable since olden days and utilized widely for construction of civil engineering structures.

Compare to ordinary beams arches are more economical especially for large spans because of higher load taking capacity. The flat arch is used over small openings and the segmental arch of small is more common for door and window openings. The decision of kind of arch depends upon the geometry of the arch and the desired architectural effect. Where the light abutments are available and reaction is minimum there the semicircular arch can be utilized, for uniform loads the parabolic arch is suitable and for loads which increase towards the springing as in the case of the filled spandrel arch the elliptical arch is more suitable. Masonry is normally recommended for the construction of superstructure and substructure parts of the building. In a structures where walls as significant roles and maximum load and also to subdivide the space on affording fire and weather protection etc. Solid concrete blocks prisms have also been constructed to study the load carrying capacity.

2. Literature Review

Various literatures regarding the properties of solid concrete blocks, mortar, masonry and arches have been studied in detail and these information are very much useful in the present work for the comparison purpose.

Fouad M. Khalaf in this paper for the design of masonry walls the flexural bond strength is specifically needed to design of masonry walls subjected to horizontal forces applied normal to the face of the wall, such as wind forces. To determine the flexural bond strength researchers and standards have suggested different kinds of specimens and test procedures. The outcomes inferred show that the proposed new specimen and test methodology are fit to deciding the flexural bond strength effectively and precisely.

T.S Nagaraj and Zahida Banu studied the effectiveness of utilization of dust collected from quarry and stone pieces as an aggregate in PCC. Their investigation as to how the strength data of trial mix itself encompasses the synergetic roles of those variables, thus sampling further re-proportioning to obtain desired level of workability and strength. He concluded that pebble because of texture with smooth surface decrease the strength of concrete

Saranga Pani, Shesha Prakash and Ganesh Mogaveer have also studied the structural behavior of PCC arches. For a particular span of the segmental arch the research was conducted. They made an attempt to study the influence of varying the geometric dimensions of an arch. The data available on the exploratory investigations on the arches are constrained. This has prompted to take up the detailed experimental studies on the strength and

behavior of arches constructed using variety of materials taking into account the different factors in the present research work.

G. Sarangapani, B.V.Venkataramana Reddy and K.S. Jagadish have carried out experiments to understand the nature of stresses developed in the mortar joint and solid block in the masonry. The outcomes uncover that the solid blocks around Bangalore with low module contrasted to conventional mortar. The solid block modulus is in the range of about 5 to 10% of the modulus of 1:6 cement mortars. This sort of circumstance prompts a masonry where mortar joints create lateral tension while solid block creates lateral compression (triaxial) and this is an adverse situation due to the brittle nature of mortar.

Ganesh B. Mogaveer(2009) has carried out detailed investigation on studies on laterite block units and also laterite block masonry studies like water transportation study, strength behavior study.

3. Test Program

Experimental investigations are planned to study the behavior of segmental solid concrete arch. Cement mortar of 1:6 proportions for construction of arch and spandrel walls have been considered by flow test results. Solid concrete block of CS 3.93MPa in wet state and 5.32MPa in dry state was used in the construction of solid concrete block arch.

Methodology

Arches are constructed between two abutments. Over a 1:4:8 cement concrete bed the abutment was constructed. The safe bearing capacity of soil over which abutment built was 300kN/m^2. Using 1:6 cement mortars the spandrel walls for the arches have been constructed in solid concrete blocks masonry, sand and cement has been tested as per the Indian standard certification. 28days curing also maintained using wet bags. Uniformly distributed load is acted throughout the length of the arch using loading frame. Failure load is also observed during the process of loading. Vertical deflection at in center and 1/3 of span is measured at regular loads.Plate2 shows the arch that been loaded with loading frame. After the application of load, deflection at mid and 1/3rd span has been recorded. Cracks developed in arch have been observed. Load at which first crack haven been developed is noted.

Plate 1: Deflection measurement using transducers

Plate 2: Loading of solid concrete block using loading frame

4 .Results And Discussions

Load deflection variation has been represented in table 1. It is observed that its maximum load taking ability of such arch is 26.067kN/m. For a particular span with variable parameter as width, rise and thickness improvement in the ability to sustain the load can be observed. The preliminary level of crack is observed at failure load of 80%. Because of formation of hinges the arch has failed and abutments are very strong have not failed till the failure of arch.

It is clearly notified during experimentally investigation that load and deflection variations are proportional upto certain limit. The deflection was zero till the load of 6.11kN/m at both left $1/3^{rd}$ and right $1/3^{rd}$ span of arch and deflection at mid span was zero till 3.083kN/m. Further increase in load increases the deflection at regular intervals as shown in Fig 1. First crack was observed at a load of 17.658kN/m. and maximum load attained was 26.067kN/m and then it has decreased drastically.

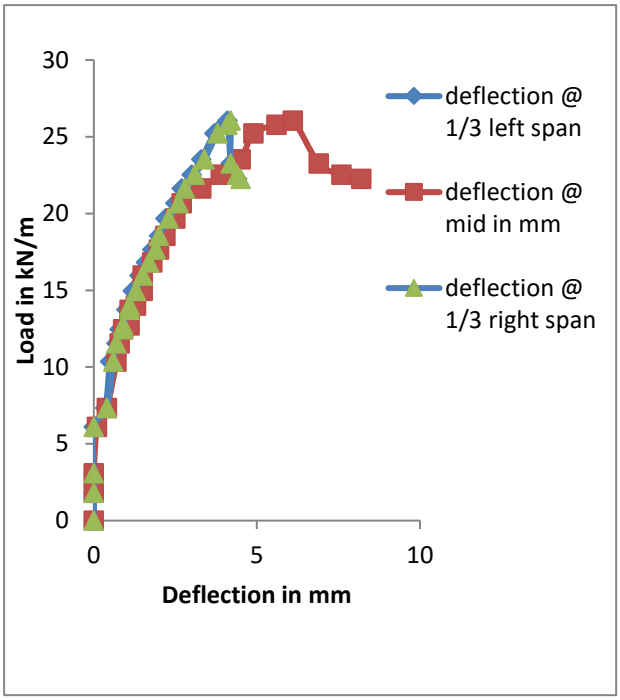

FIG 1: Variation of deflection with Load

Table 1: Load Deflection Variations

LOAD(kN/m)	DEFLECTION @ 1/3 LEFT (mm)	DEFLECTION @ MID (mm)	DEFLECTION @ 1/3 RIGHT (mm)
0.000	0	0	0
1.822	0	0	0
3.083	0	0	0
6.110	0	0.1	0
7.343	0.35	0.4	0.4
10.371	0.5	0.7	0.6
11.548	0.7	0.8	0.7
12.473	0.8	0.9	0.9
12.725	0.9	1.1	0.9
13.734	1.0	1.1	1.1
14.014	1.1	1.3	1.1
14.967	1.2	1.5	1.3
15.976	1.4	1.6	1.5
16.817	1.6	1.8	1.7
17.658	1.8	2.0	1.9
18.555	2.0	2.2	2
19.676	2.2	2.5	2.3
20.685	2.5	2.7	2.6
21.638	2.7	3.3	2.8
22.535	3.0	3.9	3.1
23.544	3.3	4.5	3.4
25.226	3.7	4.9	3.8
25.786	4.0	5.6	4.1
26.067	4.1	6.1	4.2
23.264	4.2	6.9	4.2
22.535	4.3	7.6	4.4
22.255	4.4	8.2	4.5

5. Conclusions

1. The compressive strength of masonry has a definite relation with the characteristics of masonry materials.

2. The results clearly indicates that the solid block strength, mortar strength and the bond strength as a direct relations

3. Compressive strength of solid concrete blocks is 3.93Mpa to 4.6 MPa and is above the minimum prescribed value of 3MPa

4. Water absorption of solid concrete blocks is 7.365%. which is less than the permissible

5. First crack has been observed at the load of 17.658kN/m which is around 80% of ultimate load.

6. The maximum load carrying capacity of the solid concrete block is 26.067kN/m.

7. The results clearly indicates that arch with selected dimensions in the present study can be recommended upto 2 to 3 storied residential buildings

Acknowledgement

We would like to acknowledge sincere thanks to all who have helped directly or indirectly in completion of this great pape.

References

1. ASTM C-67,"Standard Tests Methods of Sampling and Testing Solid block and Structural Clay Tile", ASTM Standards,1995.
2. ASTM : C 140-03 Standard test methods for sampling and testing concrete masonry units and related units.
3. ASTM C170 (2004), Standard test method for compressive strength of dimensional stone. ASTM, Philadelphia, USA.
4. B.V.Venkataram Reddy., "Studies on Static Soil Compaction and Compacted soil Cement Blocks for Walls", PhD Thesis Dept. of Civil Engineering, Indian Institute of Science, India 1991.
5. B.V.Venkataram Reddy, Aja Gupta (2008), "Characteristics of cement-soil mortars in fresh and hardened state." 22 (2008) 1614-1623.
6. Dayaratnam, P., Ranganathan, R., Mukhopadhyay, S. and Dasgupta, N,"Experimental Investigation of Behaviour of Solid block and Reinforced Solid blockwork, Report No. DST/427/3, I.I.T., Kanpur,Feb. 1981.
7. Dayaratnam, P.,"Solid block and Reinforced Solid BlockStructures", Oxford IBH Publishing Co. Pvt. Ltd., New Delhi, India,1987.
8. G. S. Suresh, G. Sarangapani and S. N. Karnik (2004), "Strength of Stone Masonry Arches", National Conference on Materials and Structures, NIT, Warangal.
9. G.Sarangapani, "Studies on the Strength of Brick Masonry using Mud Mortar", Proc of The 4th Int. Seminar on Structural Masonry for Developing Countries, Madras, India, 1992, pp.29-35.
10. G.Sarangapani and G. S. Suresh (2002), "Use of Stone Masonry Arches in Foundations", NWABM, IISc, Bangalore.
11. G. Sarangapani, G. S. Suresh and G. Ravi (2004), " Studies on Load Carrying Capacity of Brick Arches", AMCT-04 on 21st and 22nd May 2004 at SSIT, Tumkur
12. G.Sarangapani, Sheshaprakash, and Ganesha Mogaveera (2008) "Recent Experiences in the use of stone masonry arches in foundations",FACE 08, 2nd National Conference on Focusing on Advances in Civil Engineering, TKM College of Engineering, Kollam, Kerala, India21 – 23rd February 2008.
13. Ganesh B. Mogaveer,"Studies on the Load Carrying capacity of Laterite Block Masonry Arches",National Conference on "Contemporary Civil Engineering Practices-2012,MIT Manipal