INVESTIGATION OF INTERLOCKING CONCRETE BLOCK OF DIFFERENT CONFIGURATION TO ENHANCE STRENGTH AND SEISMIC EFFECT

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Abstract — Interlocking blocks play an influential role in strength development of any structure it provides effective assistance in seismic and compression ability, Majority of constructions is possible due to blocks. These blocks comprise the different configuration of interlocking embargo with each other to resist displacement with resistibility against earthquake and sudden impacts.

In present analysis experimental analysis was performed on interlocking blocks of two configurations named as sample – 1 and sample – 2 in which four holes and three holes were implemented on concrete block to success the interlocking effect the M30 grade is used with 12 mm aggregate size, casted in mould and curing is done for 7 and 28 days total 32 samples were prepared for testing the effect of flexural and compression effect with a load of 280, 330, 360, 400 KN, thermal effect was also analyzed for analyzing thermal resistibility of interlocking block, Further seismic analysis was done using ANSYS CIVIL 15.0 to predict natural frequency, from these analysis it was observed that Sample – 2 (three holes configuration interlocking block) found to be higher strength compared to sample – 1 (four holes configuration), thus sample – 2 could be considered for future investigation in interlocking blocks.

Keywords – *Interlocking Block, Concrete, Compressive Strength, Flexural Strength, Thermal effect, Seismic effect.*

I INTRODUCTION

Interlocking Concrete Block (ICB) has been appreciably used in some of international locations for pretty sometime as a specialised hassle-fixing approach for presenting pavement in areas where conventional kinds of creation are less long lasting because of many operational and environmental constraints. ICB technology has been introduced in India in construction, a decade in the past, for precise requirement viz. Footpaths, parking areas and so on. But now being followed considerably in different makes use of where the conventional construction of pavement using hot bituminous mix or cement concrete era isn't possible or suitable. The paper dwells upon cloth, production and laying of concrete block pavement as a brand new technique in creation of pavement using Interlocking Concrete Blocks.

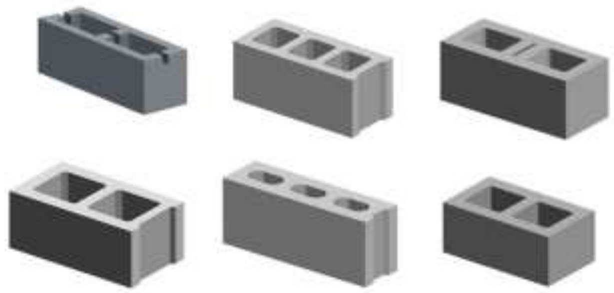

Figure 1 – Types of Interlocking Concrete Block.

II Application of ICB Technology

Some of the proven areas where ICBP technology is being applied are listed below [9 & 10]:

1. **Non-traffic Areas:** Building Premises, Footpaths, Malls, Pedestrian Plaza, Landscapes, Monuments Premises, Premises, Public Gardens/Parks, Shopping Complexes, Bus Terminus Parking areas and Railway Platform, etc.

2. **Light Traffic:** Car Parks, Office Driveway, Housing Colony Roads, Office/Commercial Complexes, Rural Roads, Residential Colony Roads, Farm Houses, etc.

3. **Medium Traffic:** Boulevard, City Streets, Small Market Roads, Intersections/Rotaries on Low Volume Roads, Utility Cuts on Arteries, Service Stations, etc.

4. **Heavy and Very Heavy Traffic:** Container/Bus Terminals, Ports/Dock Yards, Mining Areas, Roads in Industrial Complexes, Heavy-Duty Roads on Expansive Soils, Bulk Cargo Handling Areas, Factory Floors and Pavements, Airport Pavement, etc.

III. Materials

The quality of materials, cement concrete strength, durability and dimensional tolerance of paving blocks, etc. is of great importance for the satisfactory performance of block pavements. These aspects and the block manufacturing process itself, which immensely affect the quality of paving blocks, have been outlined in the Indian Roads Congress Special Publications [9]. The Central Road Research Institute (CRRI) has prepared the specifications for ICBP [10]

IV. Paving Blocks

The quality of materials, strength of cement concrete and durability as well as dimensional tolerances etc. are of great importance for satisfactory performance of block pavement. The recommended thickness of block and grades of concrete for various applications and specification for paving in which materials used for preparation of blocks, physical requirements, physical test methods, sampling and acceptance criteria has already been formulated in BIS Code [10].

Problem Identification

As per literature survey the previous investigations on flexible pavement addition of waste plastic, a studied the durability, flexibility and temperature resistance is less to the conventional mix. Flow stability and strength of pavement during high temperature and loads, hence required to be improvement in stability, strength, maintain durability and temperature resistibility of pavement due to different traffic conditions including environmental effects.

- 2.4 Problem Formulation

To resolve the above described identified problem the several sets of sample of interlocking block was prepared including different interlocking phenomenon in block mix with M30 grade, the several tests is to be performed on each sample for following outcome results i.e. temperature resistibility, compression strength, flexural strength, seismic resistibility.

Objectives

- To create samples of interlocking blocks including combination of different configuration of sample.
- To perform tests for determination of different effects this will be obtained after optimizing the interlocking block.
- To compare the results and to determine optimum strength and properties of interlocking block.
- Particular test would be performed in interlocking block sample whose optimum results are improved than other samples.

- **3.3 ORDINARY PORTLAND CEMENT**

1. The ultra tech cement of 53grade manufactured by the ULTRATECH Cement Company was considered in this study, which is Indian standard code – IS 12269:1987 having strength for 28 days being a minimum of 58MPa or 530 kg/sqcm.

Design of Concrete Mix of Grade M - 30

CONCRETE MIX DESIGN GRADE M - 30
(FOR INTERLOCKING BLOCK)

1	**STIPULATIONS FOR PROPORTIONING**		
(a)	Grade designation	:	M - 30
(b)	Type of cement	:	OPC- 53 grade confirming to IS:12269
(c)	Maximum nominal size of aggregate	:	12 mm (angular)
(d)	Minimum cement content	:	380 Kg/m³

(f)	Maximun water - cement ratio	:	0.38	IRC-SP-63-2004
(g)	Type of aggregate		Crushed angular aggregate	
(h)	Workability	:	Dry & Low Slump Mix (Clause :6.2,As IRC-SP-63 ,2004)	
(i)	Exposure condition	:	Normal	
(j)	Method of concrete placing	:	Machine	
(k)	Degree of supervision	:	Good	

TEST DATA FOR MATERIALS

(a)	Cement used	:	ULTRATECH OPC - 53 Grade
(b)	Specific Gravity of Cement	:	3.15
(d)	Specific Gravity of :		
	1) Coarse aggregate : 12 mm		2.893
	2) Fine aggregate, Clasiified sand	:	2.808
(e)	Water absorption :		
	1) Coarse aggregate : 12 mm		0.862
	2) Fine aggregate, Clasiified sand	:	1.528
(f)	AIV (%)	:	12.160
(g)	Free (Surface) moisture :		
	1) Coarse aggregate	:	NIL
	2) Fine aggregate	:	NIL

TARGET STRENGTH FOR MIX PROPORTIONING

f'ck =fck + 1.65 s

f'ck = target average compressive strength at 28 days

fck = characteristic compressive strength at 28 days

s = standard deviation

From MORT&H Table:1700-5 Current marging for M-30 grade concrete is 12 N/mm²

Therefore, target strength = 30+12 = 42 N/mm²

SELECTION OF WATER - CEMENT RATIO

From IRC-SP-63-2004, maximum W/C ratio = 0.38 (Adopted)

(Water Cement Ratio= 0.34 To 0.38)

Water Content (Ltr) = 152

CALCULATION OF CEMENT CONTENT

Water cement ratio = 152/0.38 = 400

From IRC-SP- : 63 - 2004 mimimum cement content. = 380 Kg/m3

PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE CONTENT

From IRC-SP-63 -2004, volume of coarse aggregate corresponding to 12.0 mm size aggregate and fine aggregate (Zone -II) = 0.40

Volume of fine aggregate = 1 - 0.40 = 0.60

Sample : 12 mm Aggregate							
AVERAGE % PASSING							
IS Sieve (mm)	**% PASSING**					**AVERAGE % Passing**	**Specific Limit as per Morth table - 1000-1**
	Sample 1	**Sample 2**	**Sample 3**	**Sample 4**	**Sample 5**		
20	100.00	100	100	100	100	100	100
12.5	100.00	100	100	100	100	100	90-100
10	82.05	80.13	82.45	81.53	80.99	81.43	40-85
4.75	8.28	7.87	6.31	9.78	7.16	7.88	0-10

GRADATION OF FINE AGGREGATE					
Sample : 1 (C. Sand)					
IS Sieve (mm)	**Wt. Retained (gm)**	**% Retained**	**Cum. % Ret.**	**% Passing**	**Specific Limit as per IS 383 (Zone- I)**
10.00	0.00	0.00	0.00	100.00	100
4.75	9.00	0.75	0.75	99.25	90 - 100
2.36	135.00	11.25	12.00	88.00	60 - 100
1.18	375.00	31.25	43.25	56.75	30 - 70
0.60	295.00	24.58	67.83	32.17	15 - 34
0.30	203.00	16.92	84.75	15.25	5 - 20
0.15	85.00	7.08	91.83	8.17	0 - 10
PAN	98.00				
TOTAL	1200.00				

- **3.10 MIX CALCULATIONS**

	For,					
	Cement Content (Kg)		=	**400**		
	Water - Cement ratio		=	**0.38**		
	Water Content (Ltr)		=	**152**		
	The mix calculations per unit volume of concrete is as follows :					
(a)	Volume of concrete mix	=	**1 M³**			
(b)	Volume of Cement	=	(Mass of Cement / Sp. Gravity of Cement) x (1/1000) ,			
		=	400 /3.15 x 1/1000			
		=	0.127			
©	Volume of Water	=	(Mass of Water / Sp. Gravity of Water) x 1/1000			
		=	152 /1 x 1/1000			
		=	0.152			
(d)	Volume of Admixture	=	Dry & Low Slump Mix			
(e)	Volume of all in aggregate	=	[1 - (b+c)]			
		=	0.721			
(f)	Mass of Coarse aggregate	=	e x Volume of Coarse aggregate x Sp. Gravity of Coarse aggregate x 1000			
		=	0.721x 0.40 x 2.893x 1000			
		=	834.3412	Kg		
	12 mm aggregate (40 %)	=	834.34	Say	834.34	Kg
(g)	Mass of Fine aggregate	=	e x Volume of Fine aggregate x Sp. Gravity of Fine aggregate x 1000			
		=	0.721 x 0.60 x 2.808 x 1000			
		=	1214.7408	Say	1214.74	Kg
	c. Sand (60 %)	=	1214.74	Say	1214.74	Kg

MIX PROPORTIONS FOR TRIAL NO. 3

Condition of aggregate : SSD

Cement	=	400.00	Kg
Coarse aggregate (12 mm)	=	834.34	Kg
Fine aggregate (Sand)	=	1214.74	Kg
Water	=	152.00	Ltr
		2601.08	**Kg**

NOTE : Aggregate to be used in saturated surface dry condition. If otherwise, when computing the requirement of mixing water, allowance shall be made for the free (surface) moisture contributed by the fine and coarse aggregates. On the other hand, if the aggregate are dry, the amount of mixing water should be increased by an amount equal to the moisture likely to be absorbed by the aggregates. Necessary adjustments are also required to be made in mass of aggregates. the surface water and percent water absorption of aggregates shall be determined according to IS:2386 (Part-3)

- **3.12 AGGREGATE IMPACT VALUE TEST**

Laboratory No.	MIX DESIGN M- 30	Date of Sampling	10/02/2021
Type of Material	COARSE AGGREGATE 10 MM	Sampled by	Jointly
Location of sample	103+200	Date of testing	17/02/2021

Source of material	KATARON KA KHEDA		Tested by	Jointly	
Sl No.	**Observation**	Unit	Sample No.1	Sample No.2	Sample No.3
1	Wt. of oven dried aggregate before crushing W1	gm	355.5	360.5	358.0
2	Wt. of aggregate retained on 2.36 mm sieve after crushing W2	gm	326.5	327.0	325.0
3	Wt. of aggregate passed 2.36 mm sieve after crushing W3	gm	29.0	33.5	33.0
4	A.I.V (W3 / W1) X 100	%	8.2	9.3	9.2
5	Average A.I.V	%	8.89		

Figure – Mould sample for interlocking block.

The process included the 5 basic steps and these steps are as follows:

- Weighing & Batching
- Mixing
- Placing
- Compacting
- Curing

Aggregate Sample

Figure: Sample of aggregate.

Mixing of materials

After the process of batching, the materials were selected in a ratio and they were mixed together, the process is called the Mixing. Mix was prepared using volumetric proportions for M30. The following figure shows the process of manual mixing of material.

Figure: Mixing of materials.

Placing of concrete

After mixing of materials, they were placed in the cube mould and the process of placing

Figure: placing of concrete in mould for interlocking block.

Curing of test samples

The total 24 samples were prepared using different proportions as given in Table 3-3. These test samples were cured for 7 days and 28 days respectively & the process of curing is shown in figure

Figure: curing of samples

Figure: Compressive strength test of interlocking block.

COMPRESSIVE STRENGTH TEST RESULT

Below shown table represents the comparison between compressive stresses obtained with respect to different loads applied on interlocking block in 7 days and 28 days.

Table: Results of compressive strength test for sample - 1.

(Sample - 1)		
Compressive Stress (N/mm^2)		
Load (KN)	7 days	28 days
280	17.69	26.58
330	16.66	24.25
360	15.06	23.33
400	14.96	20.96

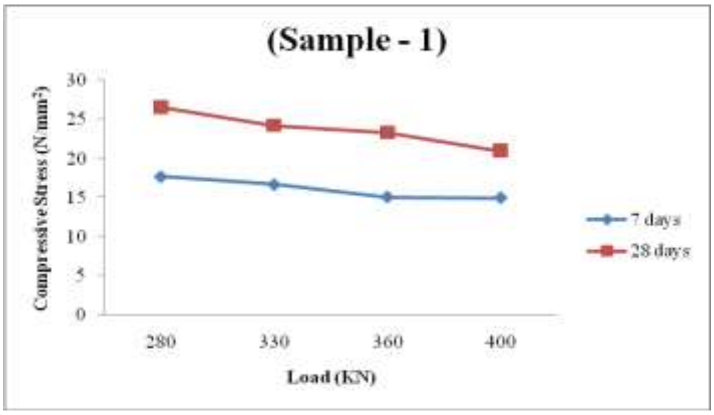

Figure: Graph shows results of compressive strength test.

Above shown graph represents a comparative analysis for compression testing in sample – 1 of interlocking block from above comparison the conclusion would be withdrawn for compressive strength of different configurations, the failure load of sample – 1 from which cracks are initiated at 360 KN load.

Table 4.2 Results of compressive strength test for sample - 2.

(Sample - 2)		
Compressive Stress (N/mm^2)		
Load (KN)	7 days	28 days
280	18.06	25.85
330	18.96	24.23
360	16.55	24.85
400	15.56	22.06

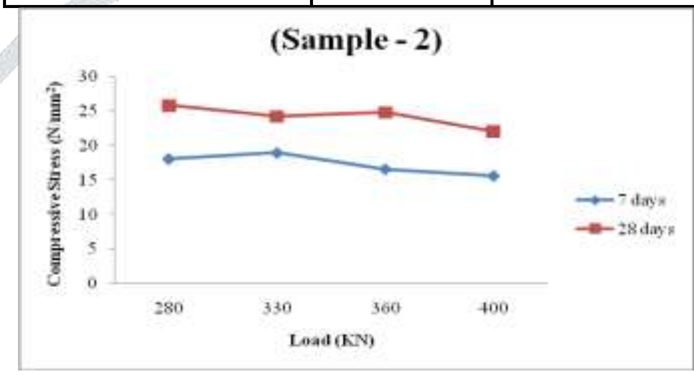

Figure: Graph shows results of compressive strength test.

Above shown graph represents a comparative analysis on interlocking block for compression testing from above comparison the conclusion would be withdrawn for different loads in 7 days and 28 days cured samples the failure load of sample – 2 from which cracks are initiated at 400 KN load.

FLEXURAL STRENGTH TEST RESULT

Table 4.3 Results of flexural strength test in different loads.

(Sample - 1)		
Flexural Strength (N/mm^2)		
Load (KN)	7 days	28 days
280	16.22	22.66
330	16.96	21.45
360	15.55	19.65
400	14.02	18.52

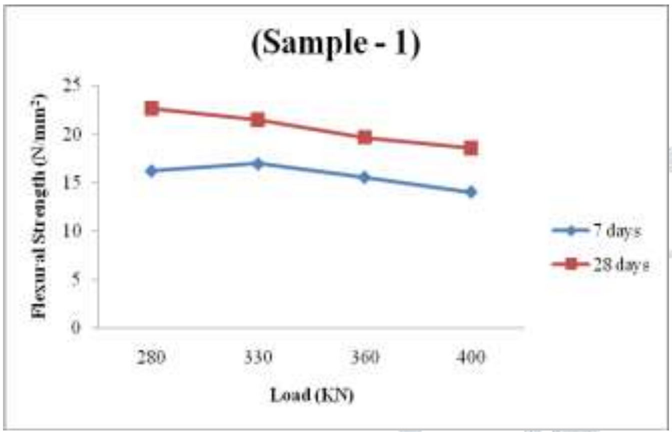

Figure 4.3 Graph shows results of Flexural strength test.

Above shown graph represents a comparative analysis of 7 days and 28 days cured samples of interlocking block for flexural testing from above comparison the conclusion would be withdrawn for flexural strength for sample – 1, the observed failure load during testing is found at 360 KN.

Table : Results of flexural strength test at different loads.

(Sample - 2)		
Flexural Strength (N/mm^2)		
Load (KN)	7 days	28 days
280	17.55	25.85
330	16.52	24.23
360	15.36	24.85
400	14.58	22.06

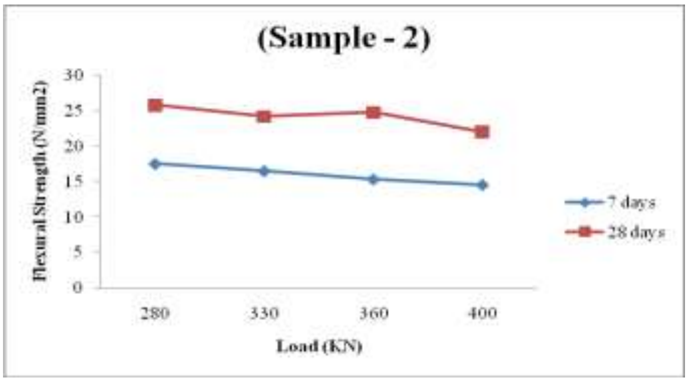

Figure 4.4 Graph shows results of compressive strength test.

Above shown graph represents a comparative analysis of 7 days and 28 days cured samples of interlocking block for flexural testing from above comparison the conclusion would be withdrawn for flexural strength for sample – 2, the observed failure load during testing is found at 400 KN.

Table 4.5 - Represents the modes and frequency of interlocking block wall of sample – 1 and sample - 2.

Mode	**Natural Frequency (KHz) (Sample - 1)**	**Natural Frequency (KHz) (Sample - 2)**
1	17.26	18.26
2	26.88	27.52
3	35.03	36.85
4	38.06	40.55
5	46.51	47.96
6	47.32	50.63
7	48.06	51.98
8	53.76	54.32
9	63.52	64.55
10	64.07	66.62

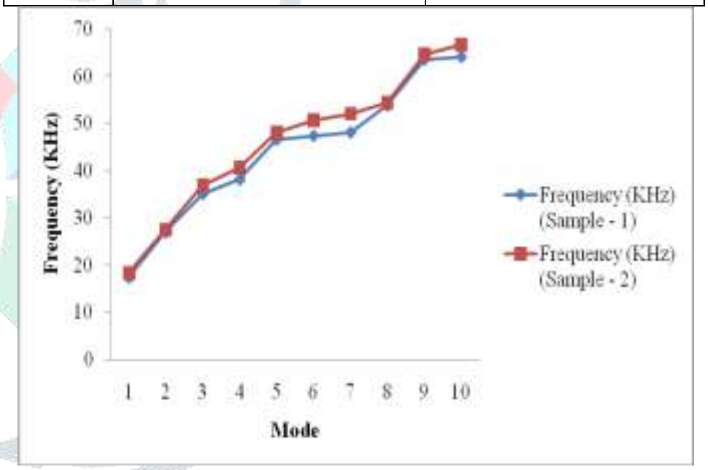

Figure – Comparison of modes and frequency of interlocking block wall of sample – 1 and sample - 2.

The natural frequencies obtained were demonstrated for sample – 1 and sample - 2 identifies the frequency obtained in 10 modes, the maximum frequency that can be considered till 6 modes only beyond this mode resonance condition will be achieved.

VII CONCLUSION

- The test results of this study concludes that there is great potential for the utilization of interlocking block of different configuration Based on present study, the following conclusions can be made.
- Interlocking block with two holes exhibits higher strength i.e. with increase in stability and ability to resist high loads with bending loads.

- The compressive strength of the interlocking block increases in different compressive loads due to interlocking between holes during combining together with cement.
- Weight of concrete interlocking block is also found 10% less compared to normal concrete block this exhibits higher strength due to interlocking effect with increased strength.
- Natural frequency of both the samples are found to be maximum this concludes that proposed configurations of concrete interlocking block design have ability to resist maximum seismic effect.

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