IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

# "ANALYSIS AND DESIGN OF DOVETAIL JOINTS IN INTERLOCKING OF CONCRETE BLOCKS BY USING ANSYS"

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***Abstract:*** **In present construction scenario, concrete blocks are well accepted units to build foundations, walls, arches and corbels. Concrete blocks have various types like solid, hollow, pavers, tree-guard blocks and they have wide range of applications like in load bearing structures, in framed structures, as ground laying units, etc. The present study focuses on another concept of interlocking blocks which is known as Dovetail joinery technique. This is the mechanism of interlocking blocks of two pieces of jigsaw puzzle. Each block of interlocking mechanism features a projection at one end and a depression at the opposite. It has its resistance to being pulled apart i.e. tensile strength high.**

**This emphasizes to use this joint where the members are in tension like retaining walls where the use of precast concrete blocks can be advantageous. Ansys software is used for the optimization of geometry of moulds of the block and to find the failure planes. In this work, concrete grade M- 30 is selected and I.S. 10262-2009 has been used for concrete mix design. Blocks of different mix have been casted and tested for various strengths like Compressive Strength, Flexural Strength and Tensile Strength. The experimental study concludes that the reinforced block has more load carrying capacity as compared to plain cement concrete block. In case of plain cement concrete in the flexural test, sudden failure of block was observed, whereas in case of reinforced block only crack propagated and the block did not fail suddenly. Dovetail joint can be effectively used in interlocking concrete blocks. It provides strong interlocking both in vertical as well as in horizontal directions.**

***Index Terms*** **– Dovetail Joint, Ansys, Compressive Strength, Flexural Strength and Tensile Strength.**

## 1. INTRODUCTION

Today, the construction industry is very vast and it is very challenging to complete various project within deadline and estimated budget with excellent quality. Precast concrete is well known technologies used for fast construction. Though technology is developed many years ago but implementation is not up the mark in our country. Precast concrete is mostly used as it has various applications. The pre cast blocks are units to built foundations, walls, arches and corbels, concrete blocks. Precast concrete construction technology is one of the promising methods to meet the huge construction demand in less time. The use of precast concrete systems offers several benefits such as rapid and quality construction to enhance health and safety measures and for lowering the cost also. One of the most popular joints in the carpentry section is the dovetail joint. This joint is very strong because of the way tails and pins are shaped. It is marked for its considerable tensile strength. Its shape and interlocking makes it difficult to pull the joint apart. This joint can be used in concrete construction where the members are in tension condition like the retaining wall.

## 2. NECESSICITY

The connections are very challenging especially in India mainly because of non- availability of tools, technology and proper equipment. Many tools required for precast joints and connections are currently imported from the other countries. Modern technology and latest equipment aren't available in India. For example, the Non-Destructive Testing (NDT) equipment which can scan and display the grout conditions in structures and depict the status of grout instantly is not manufactured in India.

The transporting and lifting equipment also aren't in enough supply and not manufactured in India to support the precast industry. So to overcome this problem there is need a joint whose connections do not require advanced tools, fasteners and easy to handle. So this experimental study has been done about the joint which provides interlocking with enough strength. Dovetail joints basically used in wood works.

## 3. OBJECTIVES

The objective of this study is to analyze the concrete block by using dovetail joint with various geometric parameters. For this the strength of block was verified by conducting compression test and flexural test and direct tension test. To check improvement of block and joint mesh reinforcement was provided in blocks.

## 4. OPTIMIZATION OF GEOMETRY

### 4.1 Optimization of Geometry-

As the dovetail joint has various geometric parameters like tenon angle, tenon neck width, tenon head width and tenon height, there can be many possible geometries which can be obtained by varying these parameters. So optimization of these geometric parameters has been done to get a geometry which will be safe.

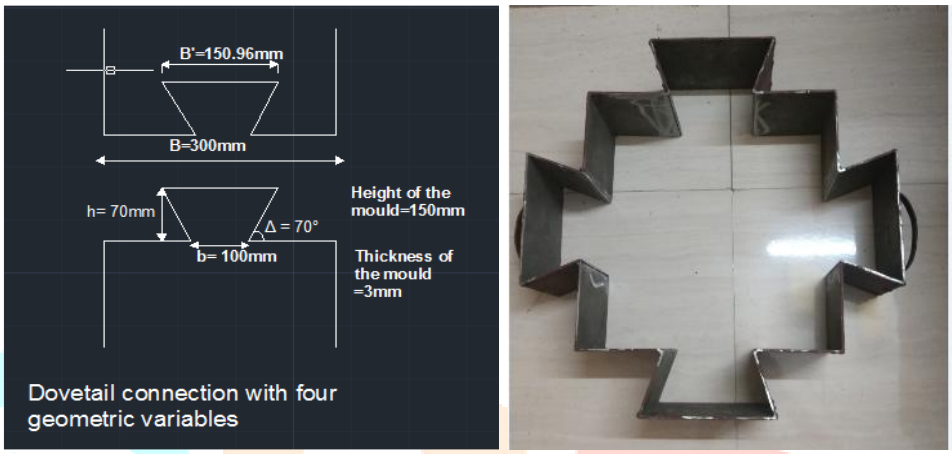


Figure 1 Trial Geometry by using Ansys

### 4.2 Final Optimum Geometry -

Total width= 18cm
Tenon neck width (b) = 6cm (1/3rd of total width)
Tenon Angle $\Theta = 70^{o}$
Tenon Height h= 40mm
Thickness of block = 50mm
Thickness of the mould =1.5mm

**4.3 Preparation of moulds for blocks –** The blocks prepared from first mould were too heavy to handle and conduct tests. So another block has been prepared which will be easy to handle for carrying out the tests and to make paving assembly using these blocks. This time half male and half female geometry has been adopted for central part because this type of geometry required less number of moulds as compared to the assembly of full male central part.
It can be seen from the above figure that one should need 4 types of moulds. The pictures of the moulds are as follows:

Mould no. 1

Mould no. 2


Mould no. 3 Mould no. 4

Figure 2 Mould Pictures

**4.4 Reinforcement-** Reinforcement having bar diameter of 1.6mm and spacing between two bars was 10 mm. The maximum size of aggregates was 10 mm so select mesh for trials. The sizes used for the mesh was 23cm X 4cm and 19cm X 4cm This mesh has been provided in the middle part of the block as a strip. A cover of 1.5 cm from bottom of block and cover of 1cm from side of block is provided.

Figure 3 Type of Reinforcement

**4.5 Details of number of blocks-**The project work include various tests to be performed on blocks. Minimum four specimens are required to carry out a test. A paving assembly is also prepared using these blocks, so before casting the number of blocks required for tests has been calculated for making assembly. Depending upon the tests to be taken, the number of blocks can be categorized and calculated in the following manner.

1. The category Type 1 block is of Plain Cement Concrete.
2. The category Type 2 block made up of steel mesh and plain cement concrete.
3. The category Type 3 blocks casted by using concrete, steel mesh and plastic aggregates.
4. Blocks casted using plain cement concrete and plastic aggregate categories Type 4.

**4.6 Concrete Mix Design** - IS method of concrete mix design is adopted for experimental work. In this work, concrete grade M-30 is selected and I.S. 10262-2009 has been used.

## 5. METHODOLOGY

For experimental investigation the following materials was mixed as per the IS and concrete of M30 grade was used to make different types of blocks. The concrete cubes of size 150x150x150 mm was casted along with seventy two specimens each for M30 grade of concrete with above four categories were cast as recommended by I.S. 10262-2009. The materials which were required for concrete mix design are Cement, Fine aggregate (Sand), Coarse aggregate, Admixture Water, Waste plastic aggregates.

**5.1 Aggregate-** Coarse and Fine aggregates should have the following properties.

Table 1 Various Tests on Aggregates

| **Physical Properties** | Coarse Aggregate | Fine Aggregate |
|---|---|---|
| **Specific Gravity** | 2.84 | 2.41 |
| **Bulk Density** | 1600 kg/cm$^2$ | 1700kg/cm$^2$ |
| **Fineness Modulus** | 4.60 | 2.84 |
| **Water Absorption** | 0.45% | 0.20% |

**5.2 Cement -** Cement grade 53 (OPC) cement was used for this experimental investigation. Only fresh cement was used. The standard tests were conducted on cement and then due result are tabulated.

Table 2 Various Tests on Cement

| Sr. No. | Test | Result | Most Specification Limits |
|---|---|---|---|
| 1 | Fineness by dry sieving (As per IS:4031, Pat 1:1996) | 1.18 | Not more than 10% |
| 2 | Consistency standard cement paste (As per IS:4031,Part 4:1988) | 35 | N/A |
| 3 | Room temperature at the time test | $28^0$C | $27^0$C+$2^0$C |
| 4 | Setting time (As per IS:4031,Part 5:1988)<br>Initial setting time<br>Final setting time | <br>48<br>285 | <br>Not less than 30 min.<br>Not more than 600 min. |

**5.3 Admixture- KEMIPLAST-600**

**5.4 Water-** The tap water in the concrete laboratory is used for preparation of concrete. The quality of water was as per the requirements of IS: 456-2000.

**5.5 Waste plastic aggregate -** Plastic Aggregates should have these following properties.

Table 3Test results of waste aggregates

| Sr. No. | Property | Specification |
|---|---|---|
| 1 | Packing type | Bags |
| 2 | Dispersion | Excellent |
| 3 | Application | Concrete |
| 4 | Shape | Triangular |
| 5 | Cut length | 10.0 mm |
| 6 | Aspect ratio (length/ diameter ratio) | 300 |
| 7 | Specific Gravity | 2.80 |
| 8 | Water absorption | Nil |

**5.6 Tests on concrete-** Various tests like Compression test, Flexural test ,Direct tension test and Pull out test were conducted to check the strength of concrete.

Table 4 Compressive Strength of concrete cubes for M30 grade of concrete for 7 days and 28 days in N/mm$^2$

| Sr. No. | Concrete Cube | Area (mm$^2$) | Compressive Strength (MPa) for 7 days | | Compressive Strength (MPa) for 28 days | |
|---|---|---|---|---|---|---|
| | | | Load(KN) | Comp. Strength | Load(KN) | Comp. Strength |
| 1 | Mix Type 1 | 22500 | 430 | 19.11 | 685 | 30.44 |
| 2 | Mix Type 2 | 22500 | 475 | 21.11 | 740 | 32.88 |
| 3 | Mix Type 3 | 22500 | 460 | 20.44 | 700 | 31.11 |
| 4 | Mix Type 4 | 22500 | 410 | 18.22 | 650 | 28.88 |

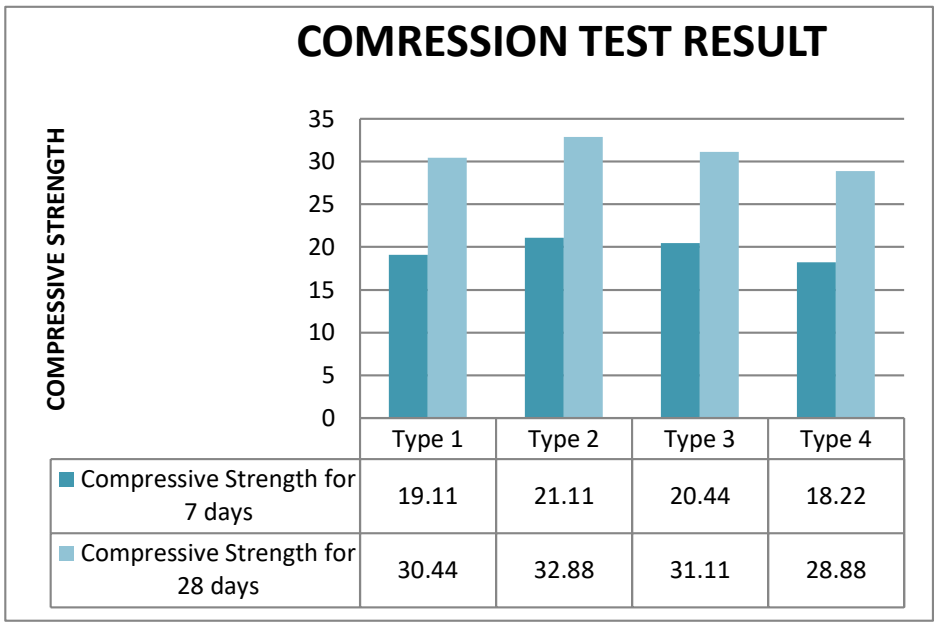


Figure 4 Comparison of Compressive strength of Concrete Cube

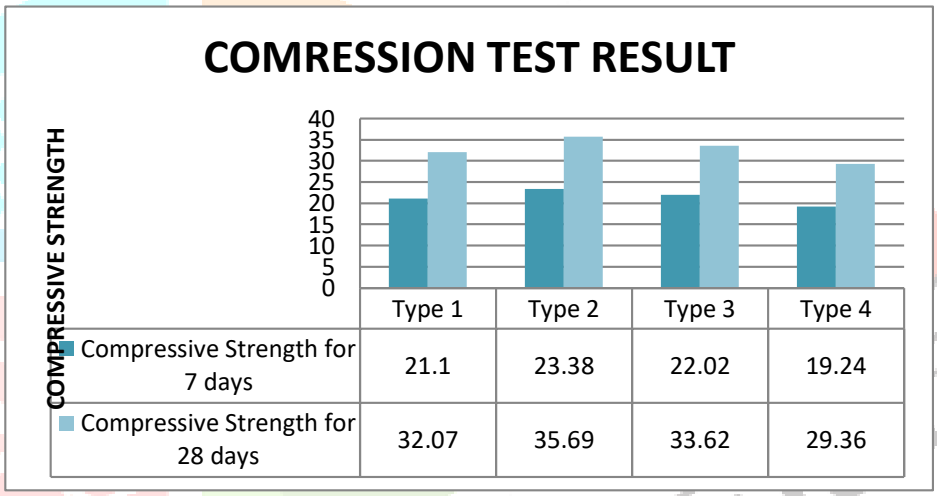


Figure 5 Comparison of Compressive strength of various mix of block

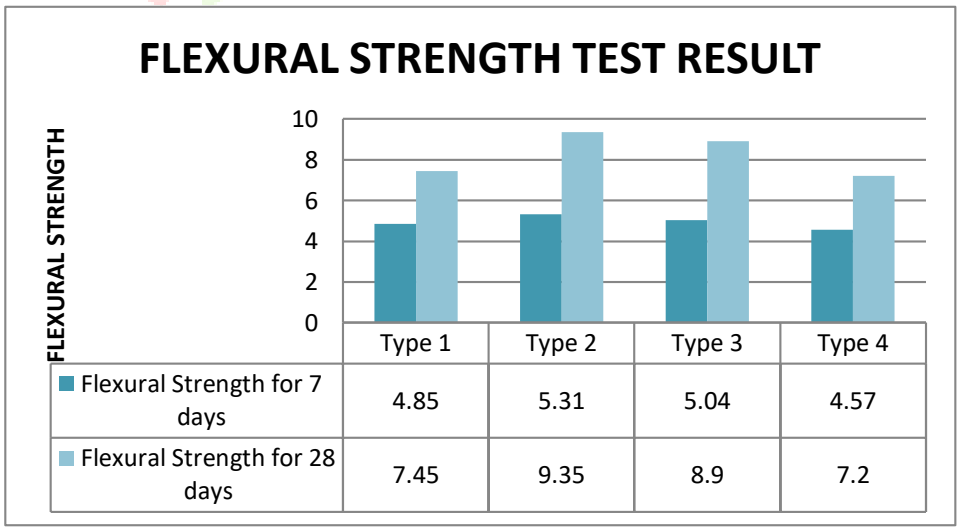


Figure 6 Comparison of Flexural strength of each mix

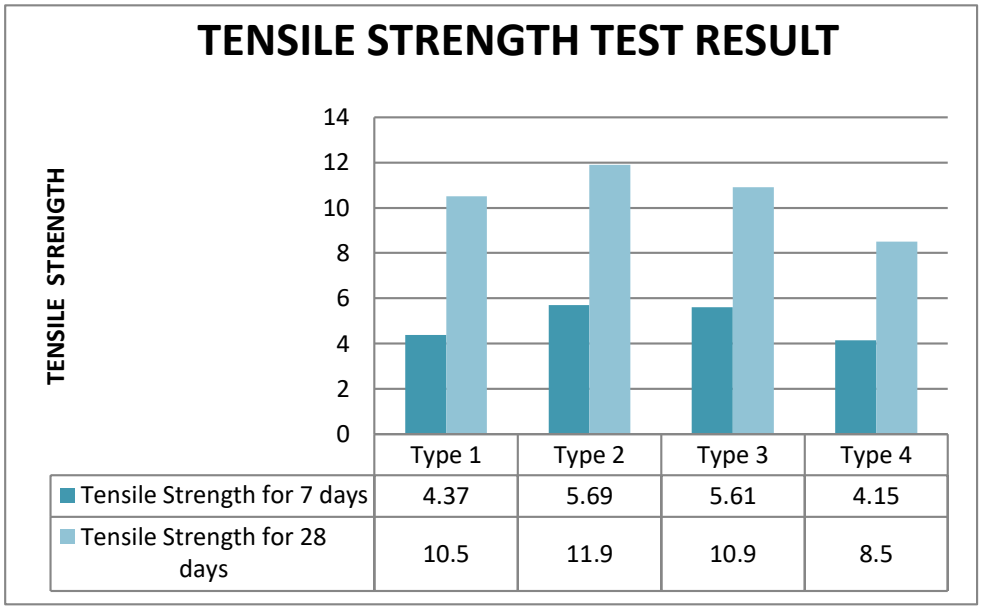


Figure 7 Comparison of Tensile strength of each mix

## 6. CONCLUSIONS

- Dovetail joint can be effectively used in interlocking concrete blocks. It provides strong interlocking both in vertical as well as in horizontal directions.
- The strength of interlocking depends on the accuracy of the dovetail part i.e. projection and depression which in turn depends on many factors like method of casting, type and accuracy of mould and the method of removing of mould after casting.
- Current pavement blocks have major issues of uneven settlement due to the instability of subgrade course, but pavers having dovetail joint will undergo no or less settlement due to the instability of subgrade as they have stronger interlocking.
- In the flexural strength test the actual point load carried by block was greater than the expected calculated load. Also the average actual flexural strength of block (4.81MPa) is found to be greater than the theoretical strength ($0.7x\sqrt{fck}$ =4.42 MPa)
- The average actual load carried by plain cement concrete block is 6.26 KN and it suggests that it can be used for regularly trafficked road, whereas actual load carried by reinforced block is greater than 7kN so they can be used for heavy duty or industrial load as per IS 15658:2006 Code.
- In case of plain cement concrete in the flexural test, sudden failure of block was observed, whereas in case of reinforced block only crack propagated and the block did not fail suddenly.
- The flexural strength of block increases with increase in percentage of steel.
- The theoretical value of tensile strength varies between 8 to 11% of compressive strength, but in my case it was found to be 4.32 MPa which lies between prescribed ranges.
- Applications can be extended by varying the geometry of blocks to suitable dimensions and suitable percentage of steel.
- From the test results got by performing compressive strength, flexural test and direct tension test, it can be concluded that the blocks of Type 2, having Reinforcement are more suitable rather than the plain cement concrete and the remaining two.

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