

# Erection of Formwork with Optimum Spacing of Joists and Stringers

D.Muthu, C.Venkatasubramanian, G.Nandhini

**Abstract:** The success of any project depends on suitable and economical formwork arrangements and it accounts about 25% in the overall cost. The project completion time depends on the erection and de-shuttering of formwork. Proper planning, management and safety is very important to finish the project within the cost budget and satisfactory quality. This study focuses on the conventional type of form work using timber joists and stringers loaded with different types of spacing in an actually erected model. The soil has been compacted, consolidated before the erection of model. After erections, the entire model has been subjected to sand bag loading with the specified loading capacity per sq. m. The deflections due to the added load on the formwork is characterized by standard deflectometer for different spacing of timber joists. Accordingly, the shores spacing have also been obtained with the designed load bearing capacity. With this study it has been found that the stability of formwork is analyzed based on vibrations and deflections. Hence the study infers that optimum spacing of joists designed should be decreased for minimum deflection. The vibrations and key factors for this erection have been identified and the results are presented.

**Key Words:** Sheathing, Joist , stringer, shores, deflection, vibration, plywood, steel.

## I. INTRODUCTION

### A. FORMWORK:

Formwork has a self-supporting ability that gives particular dimension to the flowable fresh concrete. It also has the ability to take loads of concrete and working atmospheric loads caused by building activities. Formwork plays an important role in safety, quality, time, and cost of any RC building construction. Formwork is a interim structure in the sense that.

- It can be erected quickly.
- Has high imposed loads during placement of concrete.
- Ease of removal and fixation of formwork.

Normally the formwork consists of joist connections, braces and laces, anchorage, and other devices. The term "Temporary Structures" may not fully mean to be temporary, since some forms, tie hardware, and accessories are prone to repetitive loads, which needs high durability and maintenance characteristics and design that maximizes productivity.

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### B. FUNCTIONS OF FORM WORK:

- Forms mould the concrete to required shape and size.
- Formwork act as a temporary structure that supports fresh concrete, self weight and the construction loads.

### C. REQUIREMENT OF GOOD FORMWORK:

- Impenetrable to withstand all types of loads
- Tight packing near joints for good holding of concrete.
- Construction of formwork should ensure easy erection and removal.
- Cheap availability of material for easy access and transport is also recommendable.
- It should be as light as possible.
- At the same time it should be in a position to be reused

### D. TYPES OF FORMWORK BASED ON SHAPES:

- Column formwork
- Beam formwork
- Slab formwork
- Wall formwork

## II. OBJECTIVE

- Formwork is the major portion of the building construction.
- This project includes the experimental study of slab formwork, employed for various concrete construction with different dimensions using optimum section (skeleton) of sheathing, joist, stringer and shores.
- A comparison is made between timber and steel formwork system.
- The objective of this project is to determine the stability of slab form work to support construction loads and vibratory loads by computation of properties viz., vibration and deflection.
- To determine the optimum spacing of members of slab form work. To perform a graphical comparison between the obtained values for the economical evaluation.

## III. LITERATURE REVIEW

The superlative design of some floor system, together with composite slab, one way waffle slab ,and formwork of concrete slab is performed[1].



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Along structuring with the reliability analysis for predictable steel scaffolding shoring structure deploy recent survey data on geometric and mechanical properties of steel scaffold members[2].The dynamic characteristic of a scaled base slab are determined for different ground condition[5].The conceptual design ,the analytical modeling of the load bearing behavior and the bending tests that demonstrate its structural feasibility[7].The main aim is to study primitive dynamic properties of an esteemed brick masonry upend bell-shaped, with the finite element analysis[4].

### IV. METHODOLOGY

**General:** The general methodology of the present project is as follows:

1. Collection of materials
2. Loading the formwork.
3. Calculation and analysis
4. Result
5. Conclusion

#### A. COLLECTION OF MATERIAL:

Plywood and steel are used as sheathing material. 100x100 mm timber and H16 beams are adopted for joist and stringer. Shore made of timber and steel is 48.3mm diameter. Vibrators are used for compaction of concrete. Vibration meter and deflectometer are taken.

#### B. MEASURING DEVICES:

Vibrators: In our project, needle vibrator is used for compaction of concrete.

- It comprise steel tube with one end closed and rounded having an eccentric vibrating element inside it.
- This steel tube called pokes is affixed to an electric motor. Size of steel tube is 40-100mm dia.
- Frequency of vibration ranges from 3000-6000 rpm. Period of vibration is 30sec-2mins concrete should be proped in layers not more than 600mm high.

#### C. VIBRATION METER:

Vibrators produce vibration in the concrete. Vibration is measured in terms of frequency using vibration meter. The unit for frequency is hertz.

#### D. DEFLECTOMETER:

Deflectometer is the device consists of dial gauge, used to find the deflection when the loads are applied. The least count of deflectometer is 0.01mm The unit of deflection is mm Figure

3.1

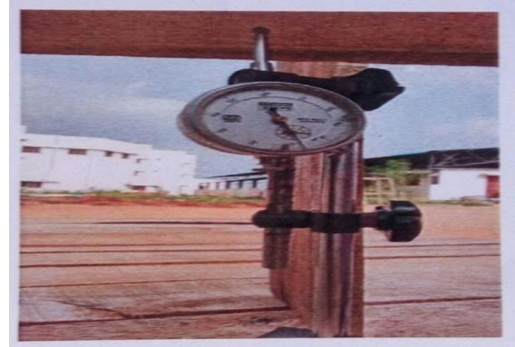


Figure1 – Deflectometer

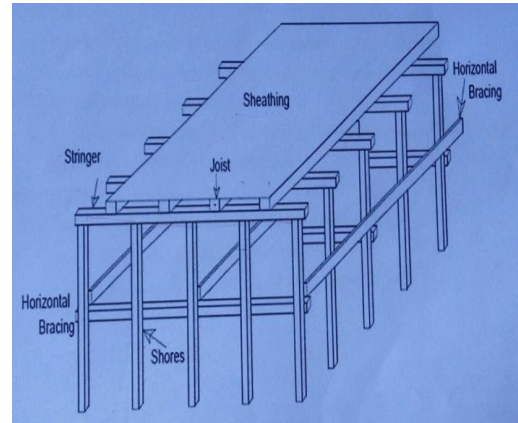


Figure2 –Components of formwork

### V. THEORETICAL PROCEDURE

Slab thickness=150mm

12mm plywood as sheathing,100mm x 100mm timber beam as the secondary and primary beam are available.

Shores = 6 feet

**Computation of loads:**

Self weight of concrete slab =  $0.15 \times 26 = 3.8 \text{ KN/m}^2$

Imposed load =  $1.5 \text{ KN/m}^2$

Load of formwork =  $0.3 \text{ KN/m}^2$

Total load on formwork =  $5.7 \text{ KN/m}^2$

**Formulas:**

Area =  $B \times D$  ;  $I = BD^3/12$  ;  $Z_{xx} = 1/(D/2)$

$E = 7700 \text{ N/mm}^2$

**Theoretical procedure for timber and steel formwork:**

**Source:** As per code Timber- Is:399-1963 , steel -Is:800-2007 ,plywood- Is :4990-1993

Type of design	Span based on bending moment	Span based on shear force	Span based on deflection	Load

Design of sheathing	$M=wL^2/8 \leq 0.2$	$Q=5W/6$ $L/8 \leq 6.1$	$\Delta=WLs^4/EI \leq 360$ $\Delta=WLs^4/185EI \leq 360$	W=total load
Design of secondary beam	$M=W_s L^2/8 \leq 1.167$ $M=W_s L^2/8 \leq 3$	$Q=W_s$ $L/2 \leq 6$	$\Delta=5W_s Ls^4/384EI \leq L/360$	$W_s = \text{width} \times W$
Design of primary beam	$M=W_p L^2/8 \leq 1.167$ $M=W_p L^2/8 \leq 6$	$Q=W_p$ $L/2 \leq 6$	$\Delta=5W_p Ls^4/384EI \leq L/360$	$W_p = \text{spacing}$

Table I Span and load details based on bending

**Design of shores /props:** The total load on the intermediate shores/props = total load on the formwork x spacing of primary beam x span of the secondary beam. The total load value should be less than the permissible load carrying capacity of props(20Kn).

**Calculation of frequency:**

$F=1/2\pi\sqrt{k/m}$  ( $k=\sqrt{p/\Delta}$ )

**Calculation of deflection:**

The acceptance and frequency used values for permissible deflection are given. sheathing should be less than 1.6mm.[Hao Zhang et al.(2012)]

**VI. PRACTICAL PROCEDURE**

This table indicates the theoretical and experimental values of sheathing , secondary beam , primary beam , shores for both timber and steel `formwork.

MEMBER / CONDITION	THEORETICAL		PRACTICAL		
	Dimension (mm)	Spacing (mm)	Dimension (mm)	Spacing (mm)	
SHEATHING	120x650x12	1200	1200x650x12	1200	
	120x650x12	1200	1200x650x12	1200	
SECONDARY BEAM	100x100	550	100x100	550	
	65x160	600	65x160	600	
PRIMARY BEAM	100x100	1600	100x100	1600	
	65x160	2000	65x160	2000	
shores	Base plate	150x150	1000	150x150	1000
	Shore	60x48.3		60x48.3	
	Base plate	150x150	1000	150x150	1000
	Shore	60x48.3		60x48.3	

Table II theoretical and experimental values



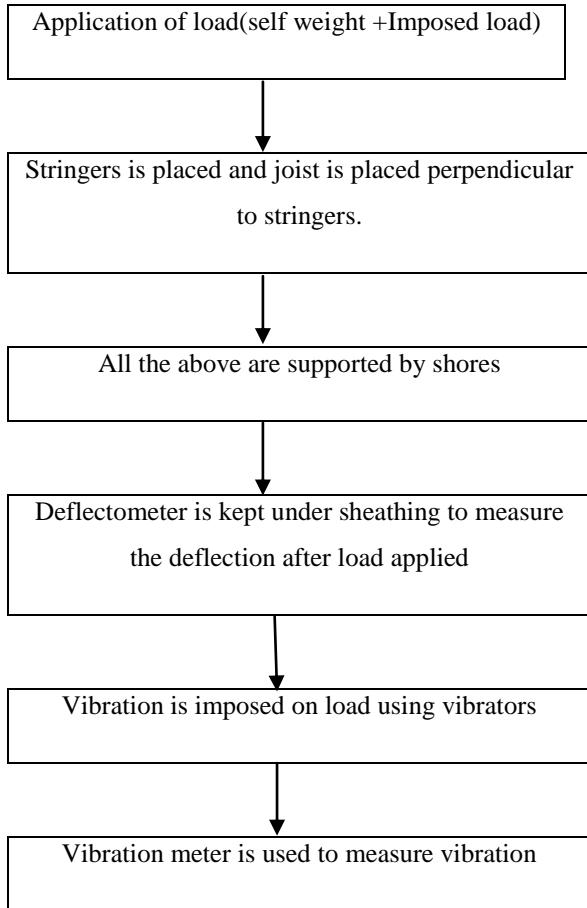
Figure3- Steel formwork



Figure4 -Timber formwork

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### Practical procedure for timber and steel formwork:



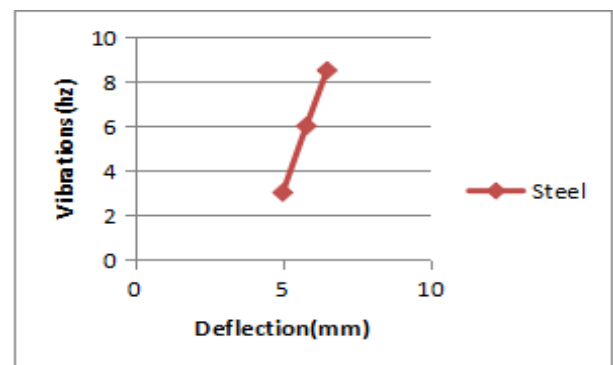
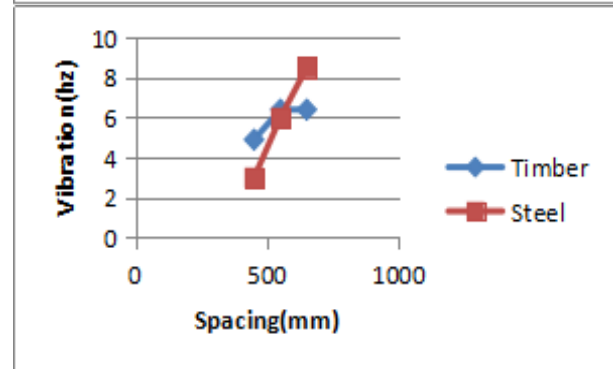
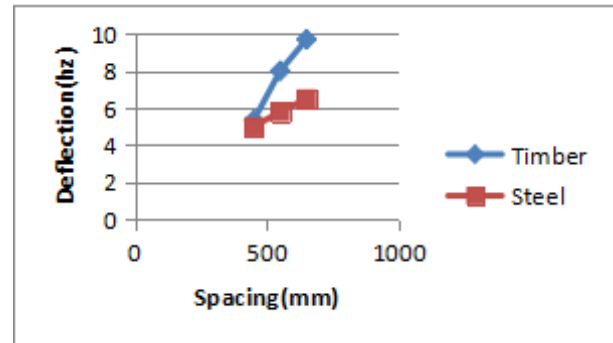
Steel slab formwork			
STABILITY PROPERTIES	Trail	VIBRATION(Hz)	DEFLECTION(mm)
THEORETICAL	1	0.8	1.6
	2	0.8	1.6
	3	0.8	1.6
PRACTICAL	1	3	5
	2	6	5.8
	3	8.5	6.5

**Table III Onsite steel slab formwork**

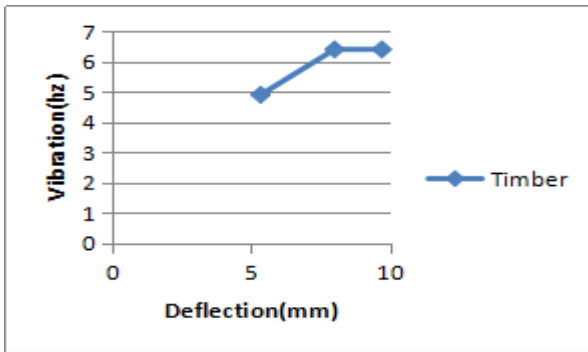
Timber slab formwork			
STABILITY PROPERTIES	Trail	VIBRATION(Hz)	DEFLECTION(mm)
THEORETICAL	1	1.4	3

	2	1.4	6
	3	1.4	8.5
	PRACTICAL	1	4.9
	2	6.4	8
	3	6.4	9.7

**Table IV Onsite timber slab formwork**







From the above graph it is known that **optimum spacing of joist designed should be decreased for minimum deflection and vibration.**

## VII. CONCLUSION

Quality of steel formwork is easier to maintain as compared with timber formwork. Formwork is essential part of concrete work. spacing of the secondary beam executed practically should be less than the designed spacing. Hence minimum spacing gives a stable structure.

In order to ensure good results formwork should be properly designed and used. The cost of formwork varies between 10% to 20% of the structural cost. by employing good formwork, finishing cost can be reduced. Proper engineered formwork, ensures safe and quality construction of durable and enduring structures.

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