PLANK & JOIST ROOFING SYSTEM

Production and Construction Guide

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Disclaimer

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INTRODUCTION

This manual has been prepared as part of a project on '*Delivery Model for Eco-friendly Multi Hazard Resistant Construction Technologies and Habitat Solutions in Mountain States',* which has been implemented in Uttarkashi (Uttarakhand) under the TIME LEARN (Technology Innovation in Mountain Ecosystem Livelihood Enhancement through Action Research and Networking) programme of the Department of Science and Technology. The project envisage to introduce new system of construction in the region which are resource and energy efficient, can be produced locally in a decentralized production setup, cost effective and easy to adapt. Considering all the above factors, **Precast Reinforced Cement Concrete (RCC) Plank and Joist roofing technology** was proposed in the region. The technology was produced locally at an enterprise unit setup developed under the project. The local artisans and entrepreneurs were trained in the technology specifications, production and its implementation through demonstration buildings at the project area.

This manual has been prepared as a guide for the use of building artisans, entrepreneurs and government officials for production and implementation of Plank and Joist Roofing technology in mountain regions. The manual is comprised of six sections – First, **Background** which covers a brief about the Plank and Joist technology and its application in the context of Uttrakhand region, Second, **Technology Profile** covers all the design and technical details of the technology. Third, **Production Infrastructure** covers all details of equipment, space and material and manpower requirement for the production of Plank and Joist. Fourth, **Production Process** covers the production details and specification of the technology. Fifth, **Construction Process** covers the construction details and specification of the technology and Lastly**, Communication Products** shows all the posters developed for the community trainings.

Background

Construction practices in the mountain regions have been changing rapidly, mainly under the influence of cement-based practices. These are perceived as stronger, particularly to resist earthquakes and the penetration of cement and workforce from plain regions have accelerated this change. As a result, brick-and-RCC type construction is rapidly becoming common without understanding technical correctness. As a result, unsafe and thermally uncomfortable buildings are being constructed, traditional skills are being eroded and energy is being injudiciously expended in transporting building materials like steel and cement from faraway.

Such construction practices were particularly assessed in villages of Uttarkashi district of Uttarakhand. Some common RCC construction practices that were observed comprised of typically - 2.5 inch- 3 inch thick RCC slabs supported on 9 inch x 9 inch columns and 9 inch x 12 inch beams. With growing preference of flat roofs in the region, this was observed to be one of the preferred option for constructing intermediate slabs and roof of the houses. Inappropriate spacing of steel bars, incorrect concrete mix, inadequate concrete covering, inadequate slab thickness making it susceptible to reinforcement corrosion, poor quality of shuttering often leaves holes in supporting walls -were some of the typical incorrect practices observed in RCC roofing leading to structural instability. The new RCC construction practices co-existing with materials of old houses – like stone and timber without appropriate technicalities were also observed.

Image showing the trend of roof construction with RCC slab along in Kamad village, Uttarkashi.

All these practices add to the structural instability and vulnerability of buildings to collapse in an already disaster prone region. Hence, it was identified that there is a need of new construction materials, an alternative which can be technically standardized and easily adapted in the region. **Precast Reinforced Cement Concrete (RCC) Plank and Joist roofing technology** was introduced in the region as an alternative to RCC flab slab – which can be locally produced and its standardized production process can be easily learnt through trainings. A standardized product would add to the technical correctness and such processes also adds economic, social and environmental value to the region by generating local livelihood opportunities, involving women in the construction process and cutting down energy consumption due to reduced raw material and transportation requirement.

Under DST Time Learn project, RCC building material enterprise has been setup in Matli region of Uttarkashi district for the production of Plank and Joist roofing technology and it has been demonstrated in three demo buildings in three different villages of the district. The applicability of the technology has been demonstrated as an intermediate slab in a single and two storey building block and roof of verandah in a community building at Kamad village- Similar application have been explored in other two demonstration buildings

The technology production and construction processes were conducted with series of trainings of local masons and women groups including – RCC building material entrepreneur training, production training and hands-on technology installation training of local masons and labour of villages. These trainings followed a series of steps to introduce this technology in the region, which has been elaborated in the package along with technical specifications.

Technology Profile

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Precast RCC Plank and Joist is a system which uses precast Reinforce Cement Concrete (RCC) elements to construct a flat slab which can also be used as an intermediate floor. It consists of two types of precast structural elements- **Plank**, which is like a small component of a bigger roof slab, and **Joist,** which is a beam to divide the roof area and to support the planks. The planks are placed side by side and supported along the length of the joist. After placing the planks and joists in position, the roof is completed with a layer of nominally reinforced in-situ (on-site) concrete which ensures monolithic behaviour of all precast elements and also provides a uniformly flat finish.

Image of assembled plank and joist roofing technology

This technology has been developed by the Central Building Research Institute (CBRI) Roorkee. It has also been validated after testing by Building Materials and Technology Promotion Council (BMTPC) for construction of intermediate roof slabs.

The basic idea behind the technology is to convert the RCC slab into smaller components. This allows for much better quality control in producing RCC. It also reduces the quantity of reinforcement steel by 15-20%.

Components of Plank and Joist Technology

Reinforced Concrete (RC) Planks

These are pre-cast rectangular concrete slabs, typically 1 feet wide and 5 feet long, although the length can vary from 4-6 feet depending on size of room. The size of the plank is governed by the requirement of manual handling of the plank – so the weight of the plank should be ideally 50 kg, which can be lifted easily by two persons. Plank is tapered from the top - partially 1 inch thick at the edges and partly 2 inches by providing a haunch (of increased thickness) at the central cross-section (usually 4 inch wide) of the plank to resist stresses during handling and installation of the plank. The plank uses nominal MS reinforcement, typically 6 mm bar and concrete of grade not less than M-20.

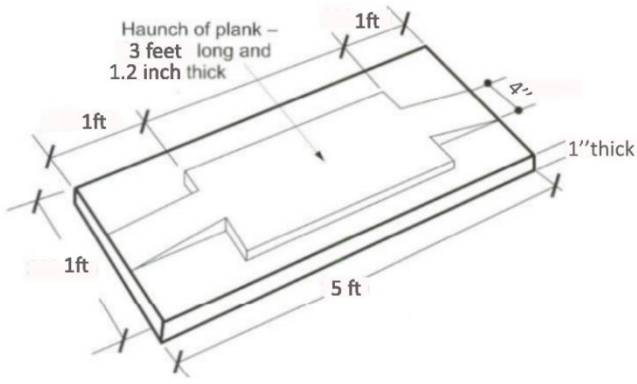


Diagram of RC Plank along with dimensions

Image of freshly casted plank

Reinforced Concrete (RC) Joist

These are partially precast beams which form a T-beam formed together with the planks on both edges and filling of in-situ concrete in the middle. The width of the joist must be able to accommodate adequate bearing of planks on both sides and the depth is governed by the span. Typically for medium spans upto 13 feet, a 6 inch x 6 inch cross section of the joist is optimum – in which case the overall depth of the beam including in-situ concrete on top the overall depth of beam comes out to be 8 inches.

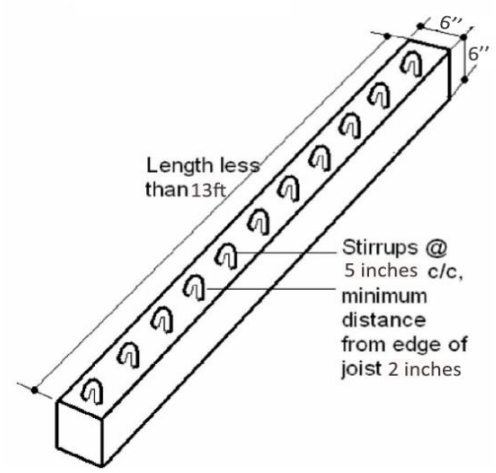
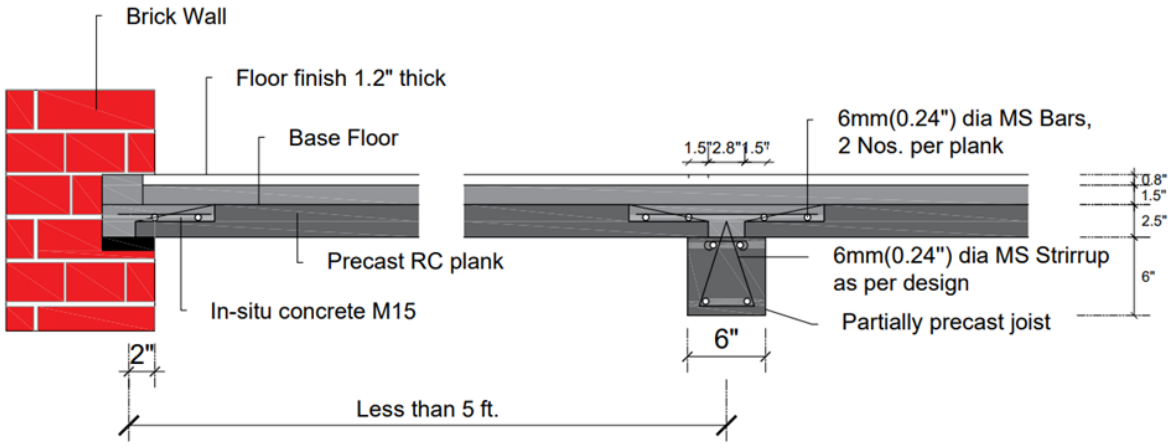


Diagram of RC Joist along with all the dimensions

Image of casted Joist

In-situ concrete

In-situ concrete over and above the precast planks and joists makes the entire assembly behave in a monolithic manner. The concrete is poured in two parts- concrete which completes the T-beam action of the planks and joist and is reinforced to resist negative moment and to provide continuity to planks in successive spans; and second layer above the top surface of planks which receives the roof/floor finish and is nominally reinforced. The first layer is basically the filling of concrete over space left beyond haunch in the planks and space left in the middle of the beam after placing of planks at the edges. The second layer is the finishing layer 1 inch thick.



Left- Diagram of assembly of planks and joist and in-situ concrete over it, Right - Image of in-situ concreting

Technical Specifications

Precast RCC Plank	Size	Width 1 feet to 1.5 feet Length 5 feet, ideally, smaller lengths possible, preferably in multiples of 1 feet. Thickness 2 inches, reducing to 1 inch at the two ends.
	Reinforcement	Nominal MS reinforcement Main reinforcement 4 No. 6mm dia Transverse 6mm dia. @ 200mm spacing
	Concrete Mix	M20 grade 1 part cement : 1.5 parts sand : 3 parts coarse aggregate
Precast RCC Joist	Size	6 inch x 6 inch upto a span of 13 feet For larger spans, either depth can be increased or the joist to be designed as a doubly reinforced beam
	Reinforcement	MS tor bars, as per design requirements of span, in accordance with IS 456:1978 For upto 13 feet span – 5 No.8mm dia, 6mm dia. Triangular stirrups @150mm spacing
	Concrete Mix	M20 grade 1 part cement : 1.5 parts sand : 3 parts coarse aggregate
In-situ concrete	Reinforcement	6 mm dia bars – 2 each per plank in the haunch portion of the plank 8mm dia tor bars in both directions @ 200mm spacing in the in-situ concrete above top of planks.
	Concrete Mix	M20 grade 1 part cement : 1.5 parts sand : 3 parts coarse aggregate

Applicability

The technology is best suited for wherever RCC slab is used for a flat slab construction. In mountain areas, verandahs are commonly constructed with flat RCC extensions from existing walls. The plank and joist system is also well suited for these verandahs. The technology can prove economical if the number of planks and joists are more- such as in the case of a 2 or 3 storied buildings. The planks and joists can be produced by a small enterprise where the infrastructure for casting, curing and storage of these elements can be installed at a low investment. Masons can be trained easily in using planks and joists to construct an RCC slab.

Advantages

Cost	Overall cost reduction by 15-20% because of reduction in steel consumption and because of faster roof construction once the walls are complete. It doesn't require any material for shuttering during construction.
Time	Saves construction time – the slab can be ready in 2-3 days as compared to at least 14-21 days for a conventional RCC slab
Employment	It also generates employment by providing an opportunity for local manpower through a production enterprise.
Quality	Centralized production provides a better, durable and consistent quality roof as compared to the quality of conventional RCC roofs in mountain regions

Production Infrastructure

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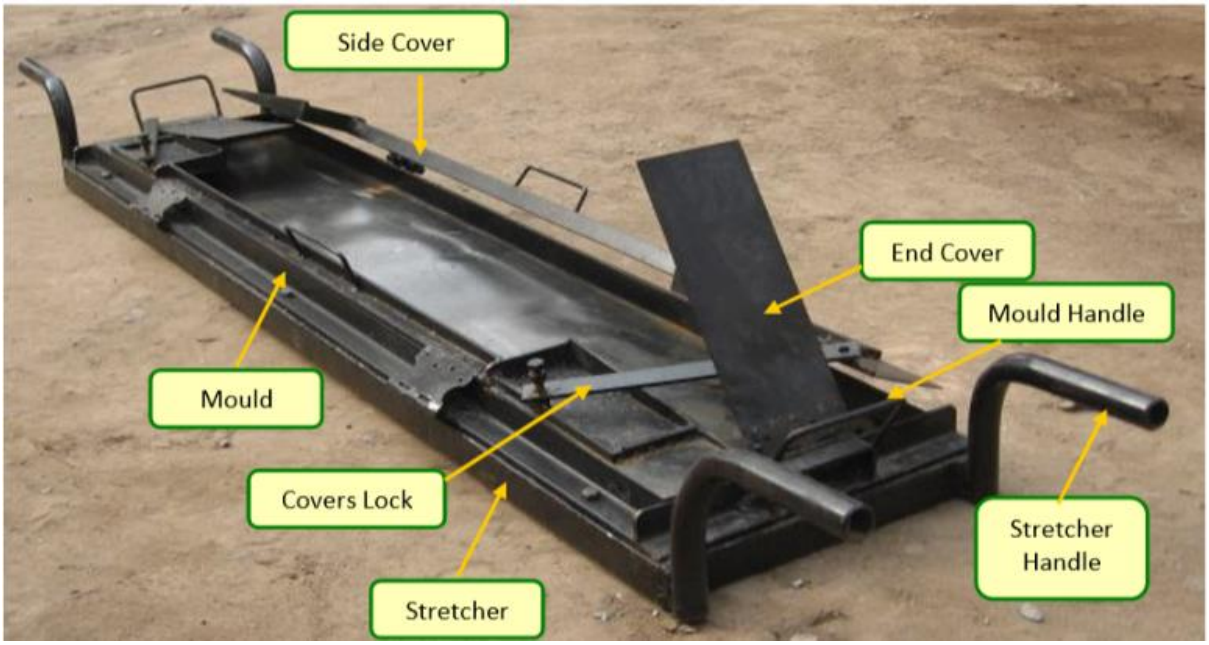
The production process for both components – Plank and Joist are similar. The production process is divided in three stages – Preparation stage, production stage and maintenance stage. The preparation stage includes setting up the production site with the required space for machinery, storage for raw materials, concrete preparation, stacking of components, curing and storage. The production stages include setting of mould, filling mould with concrete, compaction of concrete by vibration of moulds, de-moulding and curing. The machines used to produce plank and joist are developed by Technology and Action for Rural Advancement (TARA) Machine and Tech Services Pvt. Ltd. Lastly, the maintenance stage are the daily, weekly, monthly and yearly maintenance tasks to be done to continue with smooth production processes.

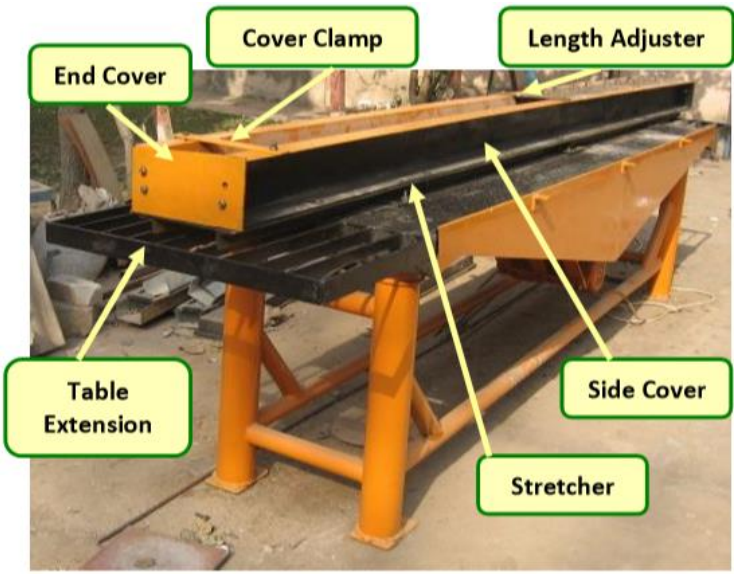
Production equipment

Below are the specifications of the machines and other infrastructure required for the production:

MACHINES	SPECIFICATIONS	QUANTITY
Plank making steel mould	Plank making metallic Mould - each set has two transferring Stretchers	5
Joist mould steel mould	Joist Mould with 1 Transferring Stretcher	1
TARA Eco Concrete – Vibrating table	Vibrating Table 13.1 x 2.9 feet, fitted with one electric vibrator of 3HP, 3 phase with attachments for Plank & Joist frame	1
TARA Eco Concrete – Concrete mixer	Concrete Mixer with gear box and 3 phase electric motor, power 3 HP	1



Mould used to cast planks along with the details of its various parts



Joist mould and vibrating machine below used to cast joist along with details of various parts of the machine

Maintenance

	AFTER PRODUCTION	DAILY	WEEKLY	MONTHLY
Casting Moulds	Scrap and clean the mould to remove any concrete left over after the use.	Scrap and clean after use. Do not allow concrete to settle on the mould while not in use.	Through cleaning of corners with brass wire brush.	Coating of surfaces with primer.
Transfer Plates	Scrap and clean after use. Use an air jet to clean the surface properly.	Scrap and clean daily.		
Drive Mechanism	Check free movement of lifting mechanism and transverse movement.		Check all electrical contacts. Check and tighten the fastening bolts.	Check rpm. Check and clean electrical contacts. Tighten the eccentric. Check bearing and lubrication.

Production unit

The most important component for setting up production unit is the identification of land at appropriate location and which fulfils the production unit space requirements. The location of the production unit must have an easy access to labour, material and transportation facilities. It is desirable to locate the production unit where there is a market potential of produced technology. The table below shows the space and other facility requirements for setting up a production unit.

PRODUCTION UNIT SPACE REQUIREMENT	SPECIFICATIONS
Total area of production yard	**4000 sq. ft**
Area for machines	25% of the total area - 1000 sq. ft
Area for curing and storage of finished products	25% of the total area - 1000 sq. ft
Area for storage of raw materials – like cement, steel bars, sand and aggregate.	30% of the total area – 1200 sq. ft (out of which 50% has to be covered)
Preparation and circulation space – preparation of sand sieving, reinforcement bending and concrete mixing.	20% of the total area – 800 sq. ft
INFRASTRUCTURAL REQUIREMENTS	
Availability of electricity for minimum 6 hours, for a full production day (Minimum 500 KW/h)	
Supply of clean water for minimum of 3-4 hours and water storage of at least 1000 litres capacity.	

Setting up Plank and Joist production unit requires an initial investment – in terms of land, infrastructural cost, cost of machines and equipments and other registration/paperwork charges. Additionally, working capital is needed for raw materials, labour and transportation. The fixed capital is one time investment which is needed for setting up the production unit and working capital is a recurring cost which would be needed as the demand of technology and production requirements.

COMPONENTS	
Land and infrastructure, includes- production unit land, levelling of land and floor preparation, construction of shed, installation of main gate, construction of water tank with approx. 1000 litres capacity, provision of electricity and water supply line.	***Costing entirely varies as per the market rate of the land and the choice of materials used in the construction of components.
Machinery and equipment, includes – Concrete mixer, vibrating table, plank steel mould and joist steel mould.	Approx. 4-5 Lakhs

Below is an estimated cost of the production unit at Matli, Uttarkashi setup in 2017. The actual cost will vary from case to case, the cost shown below were valid for a particular location for particular time period

LAND AND BUILDING	Area (Sq.ft)	Rate (Sq.ft)	Amount (INR)
Workshop Land	4,000	0	-
Shed for production area-CGI sheet on steel frame	1,000	150	150,000
Levelling of land and floor preparation	25	2,500	62,500
Gate- MS fabricated	95	1,300	123,500
Generator(future)			300,000
Sub Total			**636,000**
MACHINERY AND EQUIPMENTS	**Qty.**	**Rate**	**Amount (INR)**
TARA Eco Concrete – Vibrating table	1	125,000	125,000
TARA Eco Concrete – Concrete mixer	1	85,000	85,000
Plank making metallic mould	5	16,900	84,500
Joist mould metallic mould	1	37,500	37,500
Electronic weight machine	1	4,000	4,000
Tools for mixing concrete – spade, *belcha, tasla*			1,000
Cutter	1	25,000	25,000
Boots	5	2,000	10,000
Water Tank	1	7,000	7,000
Sub Total			**379,000**

Material and Manpower requirement for production

Material and manpower requirement has to be prepared as per daily production capacity of the production unit. The quantity of production in a day depends on the number of casting moulds available at the production unit. The casting time period on vibrating table of one plank and one joist is approximately 5-7 minutes – as per that in 8 hour of production time period in a day maximum 12 pieces of planks and 5 pieces of joists can be made. This includes 3-4 hours of casting time period and rest for preparation of concrete mix, setting up mould, demoulding etc.

The material and manpower estimate has been provided here for the quantity of one plank, one joist and combination of 100 Planks and 5 Joists –roofing material needed for the roofing area approx. 500 sq.ft.

MATERIAL	UNITS	REQUIREMENT FOR PER DAY PRODUCTION (1 Plank)	REQUIREMENT FOR PER DAY PRODUCTION (1 Joist)	TOTAL REQUIREMENT (100 Planks and 5 Joists)
Cement	Bags	0.16	0.7	19.5
Sand	Cu. m	0.008	0.03	0.95
Aggregate – 10 -12 mm	Cu. m	0.01	0.07	1.35
6mm MS Bar	Kg	1.5	32	310
10mm -12 mm MS Bar	Kg	-	17	85
MANPOWER				
For casting	No. of people	4	3	
For demoulding	No. of people		8	

**10% of wastage must be added to each material quantity mentioned above.*

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Preparation of Machines and Moulds

- Assemble the machine and check proper functioning of the machine before preparing mix. Ensure the ground of the casting yard is levelled.
- Check machine for vibration and free movement of lifting and transverse moments.
- Clean the mould with a clean dry or wet cloth and check the edges and corners of the mould for any mortar or concrete from last production. One can also use an air jet to clean the corners properly.
- Apply a fine coat of mould releasing agent (burnt engine oil) with the help of a spray or a paintbrush. Excess oil on the sides and corners should be wiped with a piece of clean dry cloth.

Preparation of concrete mix

- Concrete mix can be prepared using coarse sand or fine sand. If fine sand is being used then aggregate size must be mix of 0-10mm, if coarse sand is being used then aggregate of size 8mm can be used. The requirement is to make the mix coarser.
- All three raw materials (cement, sand and aggregate) to be mixed in 1:1.5:3 ratio - 1 bag of cement: 75 kg coarse sand: and 150kg aggregate. The raw materials must be weighed in standardized containers/ *tasla* once. Subsequently, the quantities can be measured by volume.
- Water and cement ratio is to be maintained at (0.45) 1Kg cement : 450g of water. It is critical to maintain this ratio, as high content of water in a mix would not allow the concrete to settle while casting.
- A simple test that can be done to test the concrete mix is to make a small ball of the concrete mix by hand, if the ball remains intact then the concrete mix is passed but if it is loose and gets dispersed in hand then water content is probably high and more cement, sand and aggregate to be added in the mix.

Image showing the weighing process of raw materials for the preparation of concrete mix

Image of preparation of concrete mix manually

Casting of Plank

Casting of planks includes 8 steps including– Preparation of reinforcement cage, placement of reinforcement into mould, casting of planks on vibrating table and lastly, demoulding of the casted planks from the mould.

.

- *Straighten 6mm reinforcement bars.*
- *Straighten and cut the bar as per the requirement to reduce wastage*

- *Prepare the reinforcement cage of 6mm dia. as per plank mould with three longitudinal bars – two at the edge, one centre aligned and horizontal reinforcement each at spacing of 200mm c/c Longitudinal reinforcement should be in one piece*.

- *Tie the joints with winding wire.*
- *Weld the joints to avoid displacement.*

- *Apply a fine coat of mould releasing agent inside mould.*
- *Place the prepared reinforcement cage inside the mould cover of 15mm. Adequate numbers of covers should be placed to ensure sufficient amount of concrete around the reinforcement.*
- *Close the mould along with stretcher and place the mould on vibrating table.*

- *Prepared concrete is then poured in the middle and the sides of the mould. The mix is poured to a depth such that after compaction with plate vibrator it becomes 3 cm.*

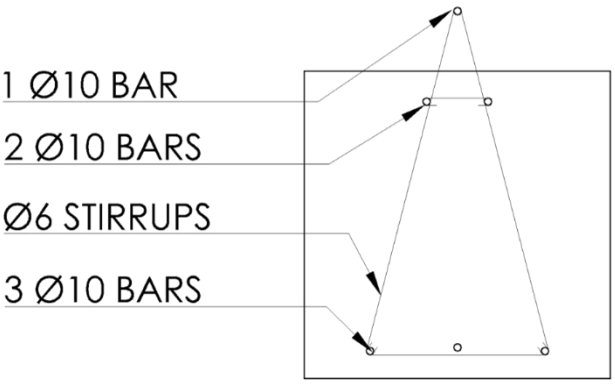
- *The casting is done in two parts. Firstly fill oconcrete in the bottom part of the plank. Start the vibration table and allow the concrete mix to compact and settle uniformly.*

- *Pour the remaining concrete in the top part of the mould and close the lid of the mould.*
- *Vibrate the concrete again till the top part of the mould has compacted properly and is of uniform level.*
- *Fresh concrete should be left undisturbed for at least 3-4 hrs till it sets.*

- *Open the lid of the mould and remove mould.*
- *Lift plank along with stretcher with help of handles provided on stretcher. Place the stretcher on ground and let concrete set for 24 hours in a covered area.*

Casting of Joist

Casting of joist includes 7 steps including– Preparation of reinforcement cage, placement of reinforcement into mould, casting of joists on vibrating table and lastly, demoulding of the casted planks from the mould.



- *Straighten and cut the 6mm and 10mm reinforcement bars. Reinforcement cage to be prepared as per 6 inch x 6 inch joist beam upto length of 13 feet – 10 mm bars are used along the length of the joist as shown in the figure and 6 mm dia. bars are used to for the triangular stirrups at the spacing of 200mm c/c.*

- *Prepare the reinforcement cage as per required length of the joist.*

- *Fix the end cover of joist on vibrating table and adjust the mould as per required length of joist.*

- *Place the prepared reinforcement cage in the mould*.

- *Pour the prepared concrete mix in the mould.*
- *Start the vibrating table.*

- *Stop the vibrating table and let the concrete to settle in the mould for 24 hours*.

- *Remove the mould after 24 hours.*
- *Lift joist along with stretcher and place the stretcher on ground and let concrete set for another 24 hours in a covered area.*

Curing of plank and joist

- The freshly cast product should be kept in the covered area avoiding direct sun and harsh wind.
- The freshly cast RCC planks and joists should be carefully transferred to the stacking yard to prevent any crack or damage.
- A curing tank is the most efficient way of curing pre-cast concrete elements like planks and joists. The tank should allow for at least 2 feet deep water.
- After 3-4 hours or when fresh concrete has hardened sufficiently, the plank and joists should be fully immersed in the curing tank for a period of 14 days. Planks should be stacked vertically along the longer edge.
- If for some reason, they cannot be cured in a curing tank, then they should be covered with hessian cloth/ gunny sack and should be kept wet for 14 days. This can be done by sprinkling water on the gunny sacks 2-3 times in a day.
- After wet curing, cure in air for another 14 days before being used in construction.

The curing process of plank after 24 hours of its casting

Common problems in production	Their solutions
How to ensure adequate vibration?	• Vibrate till the bubbles continue coming out of the concrete. Over-vibration should be avoided. This happens when water from the concrete starts to come out at the top of concrete. • Use measured quantities of concrete.
Frames stick to the mould at the time of demoulding	• Check quality of shuttering oil used. • Check for proper and uniform application of shuttering oil, especially in internal corners.
Product crack on demoulding	• Check if the product has developed adequate strength before demoulding. • In case of cold weather, increase the setting time for the mould. • If problem persists, check the quality of cement.
How to stack products to minimize breakage?	• Every day's production should be clearly identified. • Fully cured products should be stacked separately. • Follow First-in-Firs-out principle.

Quality control measures
• Ensure proper cover to the reinforcement in planks and joists. Check if any reinforcement is exposed after demoulding, especially in case of planks
• Ensure an appropriate grading of the concrete mix before casting of planks and joists. Common practices like casting of planks with a single size 6mm aggregate need more cement and result in lower strength hence should be avoided.
• Ensure adequate curing of planks and joists for at least 14 days. This can be done by inserting them completely in a water tank or by covering with moist gunny bags.
• After installation, there should be no concentrated or impact load on the plank and joist assembly till the in-situ concrete has been poured and has set
• All handing and transportation of planks should be done in vertical position as far as possible. The joists should be handled at the ends and not in the centre. Ensure to support the joist at the centre till the roof is finished completely

Construction Process

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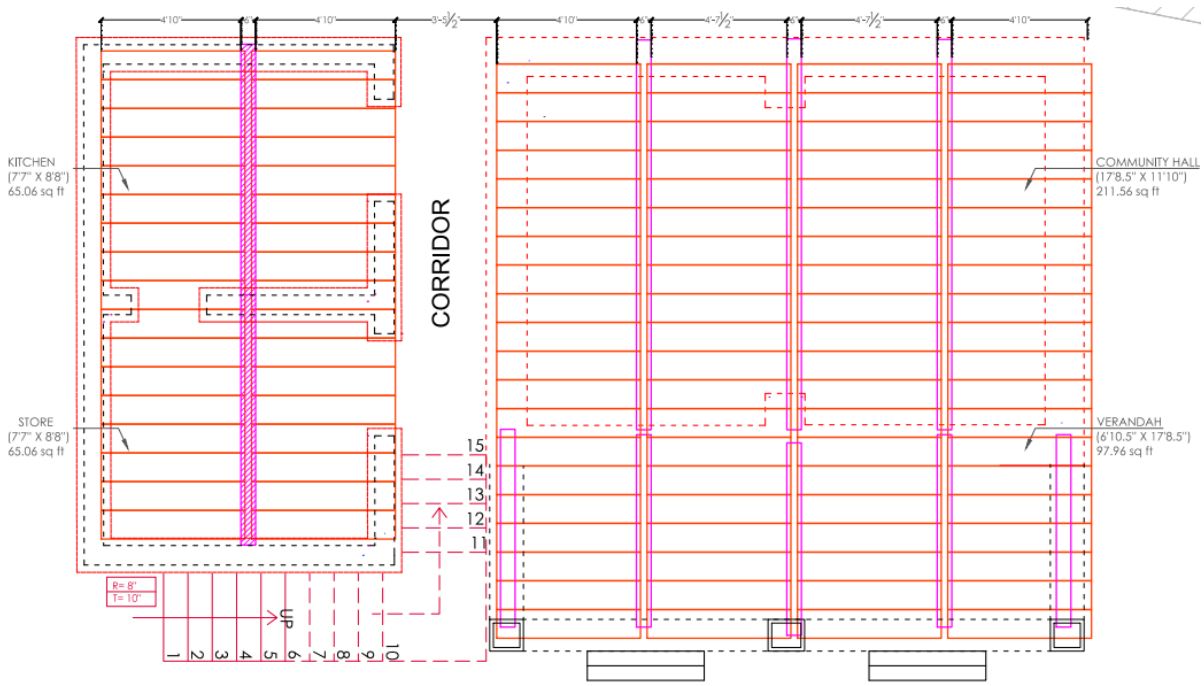
The installation of plank and joist is a simple process which can save time and cost of RCC flat slab construction in a building. The entire construction process is divided in four stage – Design, Joist installation, Plank installation and In –situ concreting. The process below shows the plank and joist installation stages in Community building at Kamad village, Uttarkashi. Plank and joist were produced for the total slab area – 560 sq.ft (including slab in hall, rooms and verandah) – with maximum room span of 17.5 feet length x 11.8 feet wide.

Design

A detailed plank and joist roof design and plan has to be prepared before placing the order for production and beginning of the installation process. It is required to avoid any last minute discrepancies in sizes otherwise cutting of plank and joist to fit in the room sizes would add to additional cost and time to the process. The plan below shows the design and detail of Community building at Kamad village, Uttarkashi prepared for total 560 sq.ft (with maximum room span of 11.8 feet width and 17.5 feet length) of slab area including roof of hall, verandah and intermediate slab of two storey block (comprising total 120 planks and 10 joists).

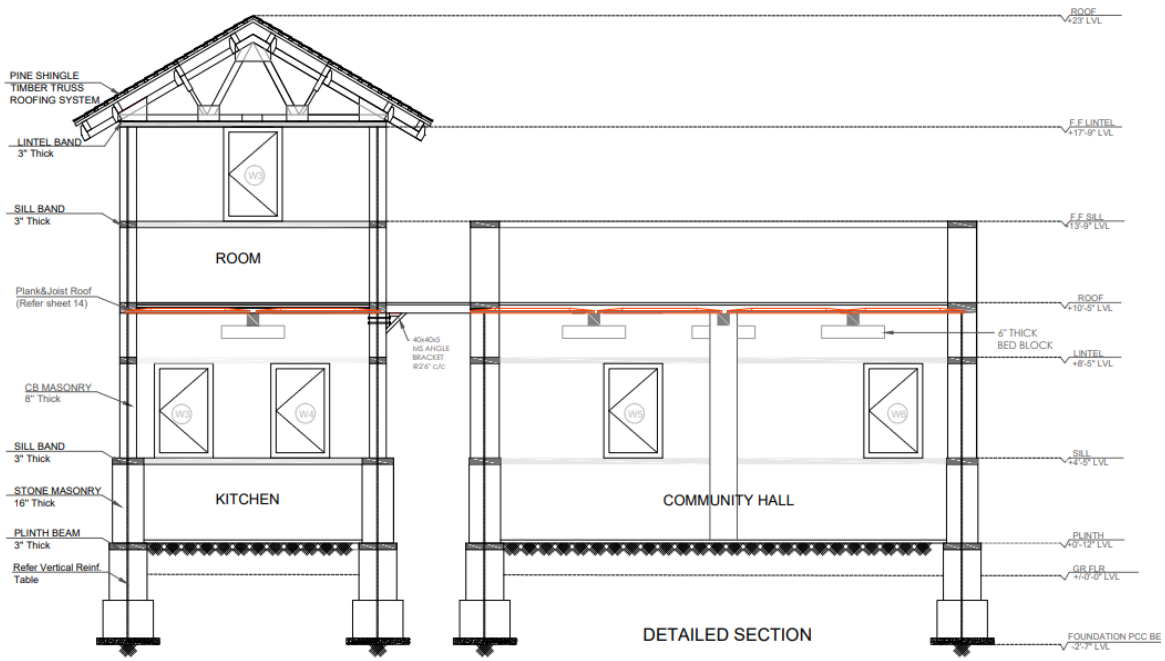
The span between two joists should be 5 feet 2 inches centre to centre – since the length of the plank is 5 feet, which needs to be placed over joists with minimum 2 inch overlap at both the ends. The maximum length of the joist is 13 feet hence, joists have been placed along the smaller span of the room (along the width). To cover the wider span joists have been placed at the distance of 4-5 feet. In verandah, joists of smaller length have been placed in alignment of verandah columns and joists placed in room. Such alignments provide structural stability and brings symmetry to the placement of planks.

The standard plank size is 1 feet x 5 feet. While width of a single plank is fixed the length is the plank can be reduced, it can be between 3-5 feet as per the design requirement. Ideally there shouldn't be more than 2-3 types of plank sizes in a design – more variations might cause difficulty during installation stage.



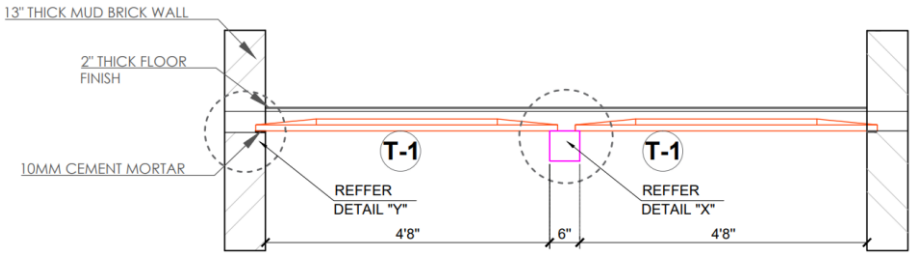
Plank and Joist roof design over community hall, kitchen/storage and verandah in Community buildng at Kamad village, Uttarkashi

Plank and Joist roof can be designed for roof slabs and intermediate slabs both following the same design principles. In the design of Community building at Kamad village – in two storey structure plank and joist slab has been designed as an intermediate slab.

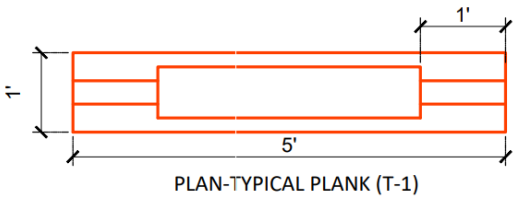


Community building section showing the plank and joist roof over community hall and as intermediate slab over kitchen area

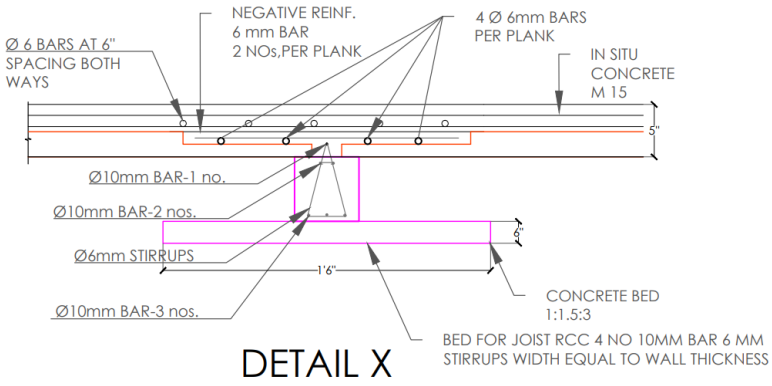
Joists are embedded in the wall over concrete bed block casted in a space left during wall masonry. Once joists are placed, planks are placed over joists with 2 inch overall at both the ends. Over Plank in-situ concreting is done with adequate reinforcement bars which also forms the roof band of the building. (Detailed steps are explained later in the section)



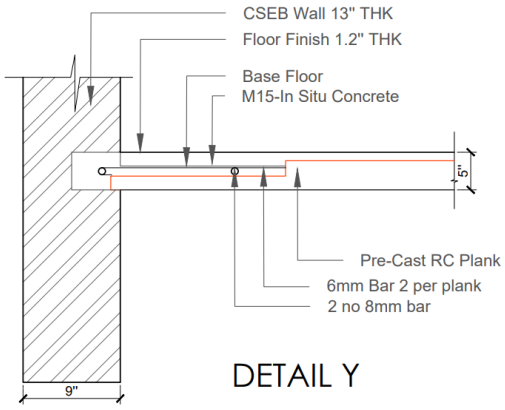
Detailed section of plank and joist roof



Plan of plank



Detailed section of plank and joist roof – showing the placement of joist, plank and reinforcement bars for in-situ concreting



Joist mould and vibrating machine below used to cast joist along with details of various parts of the machine

Joist installation

- *The centre points of all joists should be marked on the wall masonry before placing them. The length of planks and their adequate bearing on walls and joists should be taken into account before marking the centre points.*
- *After marking the centre points, place the joists accordingly.*

- *Joists can be placed at the defined spacing over a cement concrete bed, which can be in the form of a roof band, as per engineer's specifications. If the cement concrete bed is not provided, concrete blocks of size 1'x9"x3" should be placed in the wall to distribute the point load of joists.*

Plank installation

- *Planks to be placed over joist - Minimum bearing of planks should be 40 mm over wall or joist*

In-situ concrete

- *Before pouring in-situ concrete over planks and joists, additional nominal reinforcement of 4 MS reinforcement bars of 6mm dia, should be placed with every plank – 2 bars are placed on both sides of the tapering concrete portion of the plank and 2 bars are placed parallel to the joists on both sides. This reinforcement satisfies requirements for a normal residential building.*

- *Level the top surface of walls & joists with 1:4 cement sand mortar before placing the planks.*
- *Apply cement slurry over the precast joists and in haunch portions of the planks where in-situ concrete is to be laid.*

- *After laying the planks, all joints between adjacent planks should be filled with a thick paste of cement sand mortar of ratio 1:4 to fix the planks in place.*

- *Place 6mm reinforcement bar horizontally and vertically at spacing of 200mm.*
- *Pour 3cm thick layer of concrete (1:2:4) over reinforcement bars.*
- *Cure the in-situ concrete for a minimum period of 10 days.*
- *Do no remove the prop of the joists before the curing period is over and the in-situ concrete laid in the roof slab has attained strength.*

Common problems in installation	Their solutions
The spans are continuous, but the joists have been designed as simply supported.	• Vibrate till the bubbles continue coming out of the concrete. Use measured quantities of concrete.
Hanging fans from the joists?	• A fan hook should be placed in the joists while casting by providing a groove in the casting floor at the position of the hook. • Alternatively, a conduit pipe of 15 mm diameter to be embedded to hand fan by clamp.
Provision for balcony/*chajja* projection	• Balcony projections are provided along the partially precast joists. The joist is designed with an overhang carrying superimposed loads for balcony as specified in IS: 875-1964, in addition to the self-load and the load due to railing.

Material and Manpower requirement for installation

Below is an estimate of material and labour requirements for installation of 120 planks and 10 joists across slab area of around 560 sq.ft.

MATERIAL	UNITS	QUANTITY
Cement	Bags	12.5
Sand	Cu. m	0.8
Aggregate – 10 mm	Cu. m	1.7
6mm MS Bar	Kg	150
10mm MS Bar	Kg	15
MANPOWER		
2 Mason for 3 days each	Man-days	6
3 Labour for 3 days each + 5-6 people extra for the lifting of joist and planks to roof for one day.	Man-days	15

**10% of wastage must be added to each material quantity mentioned above.*

Communication Material

Government of India
Department of Science & Technology
Ministry of Science & Technology

Development Alternatives

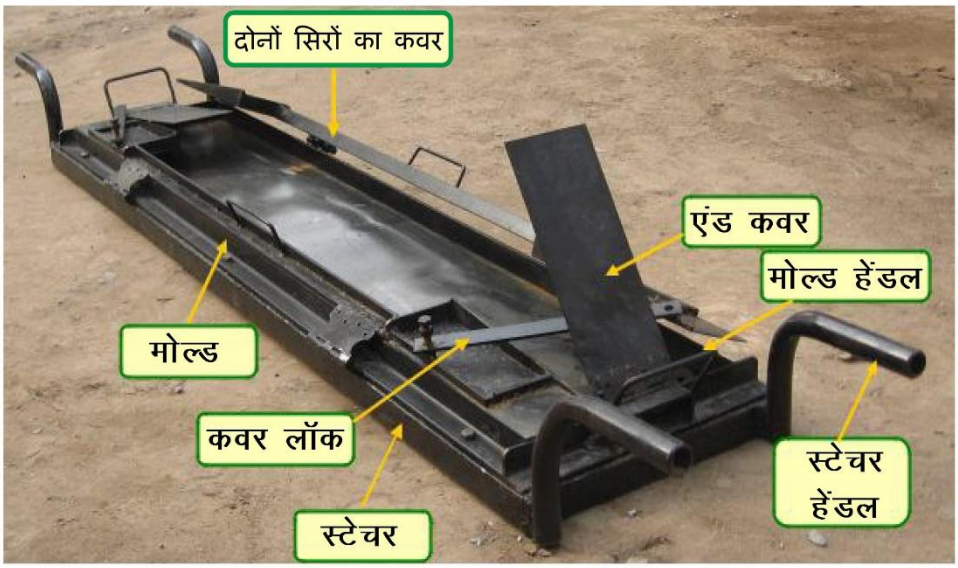
Technology and Production Poster – A3 size

प्लैंक और जॉयस्ट छत प्रौद्योगिकी

पट्टिका और बीम बनाने की प्रौद्योगिकी

मशीन का विवरण

प्लैंक पट्टिका) का फरमा



कंक्रीट की पट्टिका बनाने के लिए सरिया

माप :	5 फीट से अधिक नहीं. चौड़ाई 1 फिट, मोटाई कुल मिला कर 2 इंच 3 सूत
कच्ची सामग्री :	ओपीसी 43 ग्रेड सीमेंट, मोटे दाने वाली रेत (बालू) 3-6 सूत साइज़ की रोडी
कंक्रीट मिश्रण :	1 सीमेंट : 1.5 रेत: 3 रोडी
सरिया :	2.5 सूत 6mm) का सरिया दोनों दिशा में

Development Alternatives

Government of India
Department of Science & Technology
Ministry of Science & Technology

HESCO Himalayan Environmental Studies and Conservation

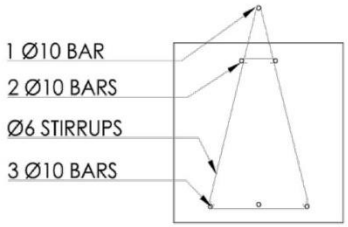
प्लैंक और जॉयस्ट छत प्रौद्योगिकी
पट्टिका और बीम बनाने की प्रौद्योगिकी

मशीन का विवरण

जॉयस्ट का फरमा

कंक्रीट बीम बनाने के लिए सरिया

माप :	6“ x 6"; 150mm x 150mm) इस साइज़ की बीम को ऊपर दर्शाए गए सरिया के साथ 13' लंबाई तक ढाला जा सकता है। इस से ज़्यादा लंबाई की बीम बनाने के लिए इंजीनियर की सलाह अवश्य लें।
कच्ची सामग्री :	ओ पी सी 43 ग्रेड सीमेंट, मोटे दाने वाली रेत
कंक्रीट मिश्रण:	1 सीमेंट : 1.5 रेत: 3 रोडी
सरिया:	2.5 सूत और 4 सूत का सरिया ऊपर दिखाए चित्र के अनुसार



Development Alternatives

Government of India
Department of Science & Technology
Ministry of Science & Technology

Himalayan Environmental Studies and Conservation

प्लैंक और जॉयस्ट छत प्रौद्योगिकी

पट्टिका और बीम बनाने की प्रौद्योगिकी

उत्पादन की प्रक्रिया (पट्टिका)

सरिया का जाल बनाएं

Ø 6mm सरिया काटे और सीधा करें

सरियों को ढांचे के हिसाबं से बांधें

बनाया गया जाल ढलाई के लिए तैयार

मिश्रण तैयार करें

4 आवश्यकता अनुसार सीमेंट, रेत, और मिट्टी को ले 1:1.5:3 के अनुपात में तोल ले

5 सूखी कच्ची सामग्री को मिलाकर उसका मिश्रण तैयार करें

6 अब मिश्रण में पानी मिलाकर एक समान मिश्रण तैयार करें

मोल्ड को तैयार करना

7 मोल्ड की सतहों के अंदर चिकनाई के लिए ब्रश से तेल लगाएं ।

8 स्ट्रेचर पर बुने हुए सरिया का जाल रखें और उसके ऊपर मोल्ड रखें।

9 सांचे के साथ स्ट्रेचर को बंद करें और इसे वाइब्रेट टेबल पर रखें

Development Alternatives

Government of India
Department of Science & Technology
Ministry of Science & Technology

Himalayan Environmental Studies and Conservation

प्लैंक और जॉयस्ट छत प्रौद्योगिकी

पट्टिका और बीम बनाने की प्रौद्योगिकी

उत्पादन की प्रक्रिया (पट्टिका)

कंक्रीट डालें और वाइब्रेटर को चालू करें।

सांचे के कोने में करणी से कंक्रीट फैलाएं।

कवर और क्लैंप को बंद करें।

13 वाइब्रेटर को बंद करें। पट्टिका के सांचे को खोलें और इसे मंजिल पर रखें ।

14 तीस मिनट के बाद सांचे को खोलें और पट्टिका को सांचे से बाहर निकाल लें ।

15 चौबीस घंटे के लिए स्टेक्चर पर पट्टिका को रखें ।

16 स्ट्रेचर से पट्टिका निकालें और इसे यार्ड स्टैकिंग पर रखें

17 बीम को मजबूत करने के लिए 14 दिन तक पानी का छिड़काव करें

18 छत को बनाने के लिए अब ये इस्तेमाल करने के लिए तैयार है

Development Alternatives

Government of India Department of Science & Technology Ministry of Science & Technology

Himalayan Environmental Studies and Conservation

प्लैंक और जॉयस्ट छत प्रौद्योगिकी
पट्टिका और बीम बनाने की प्रौद्योगिकी

उत्पादन की प्रक्रिया (जॉयस्ट)

एंड कवर को फिक्स करें और सांचे को जरूरत के अनुसार जोड़े

सांचे में आवश्यकता अनुसार लंबाई में बुना हुए सरिये को रखें

कंक्रीट को सांचे में डाले और वाइब्रेटर को शुरू करें।

4 वाइब्रेटर को बंद करें । अगले दिन तक ताज़े बीम को सांचे में ही रहने दें ।

5 अगले दिन, सांचे को खोलें और साइट कवर को हटा दें ।

6 स्ट्रेचर को ताज़े बने हुए बीम के साथ उठाकर सतह पर रख दें।

7 दूसरे दिन, बीम को सांचे से बाहर निकालें और यार्ड के सहारे उनको रखें।

8 21 दिनों तक उन पर पानी का छिटकाव करें ।

9 अब बीम छत पर लगाए जाने के लिए तैयार है ।

Development Alternatives

Government of India
Department of Science & Technology
Ministry of Science & Technology

Himalayan Environmental Studies and Conservation

प्लैंक और जॉयस्ट छत प्रौद्योगिकी

पट्टिका और बीम बनाने की प्रौद्योगिकी

करें

मिश्रण में पानी मिलाने से पहले ही सूखे मिश्रण को मिलाएं ।

मिश्रण बनाने से पहले कच्चे माल का वज़न कर लें

कंक्रीट को सांचे में भरने से पहले सतहों पर तेल लगा लें

डिजाइन के अनुसार सरिये से बने उचित डिज़ाइन का चुनाव करें

सांचे से बाहर निकालने के दौरान सांचे के किनारे को पकड़ कर ऊपर नीचे करें।

बीम बनाने से पहले वाइब्रेटिंग टेबल के साथ टेबल एक्सटेंशन फिट करें।

न करें

गैर जरूरी कच्ची सामग्री को मिश्रण में न मिलाएं

कास्टिंग के दौरान दौरान सांचे के कवर को न हटाए

बिना इस्पात के सरिये के ढांचे के बिना कंक्रीट के मिश्रण को न डालें

Development Alternatives

Government of India
Department of Science & Technology
Ministry of Science & Technology

Himalayan Environmental Studies and Conservation

Technology and Production Poster – A2 size

प्लैंक और जॉयस्ट छत प्रौद्योगिकी

पट्टिका और बीम बनाने की प्रौद्योगिकी

मशीन का विवरण

कंक्रीट पट्टिका और आर.सी.सी. बीम की छत

प्लैंक (पट्टिका) का फरमा

जॉयस्ट का फरमा

कंक्रीट की पट्टिका

माप	5 फीट से अधिक नहीं, चौड़ाई 1 फिट, मोटाई कुल मिला कर 2 इंच 3 सूत
कच्ची सामग्री	ओपीसी 43 ग्रेड सीमेंट, मोटे दाने वाली रेत (बालू) 3-6 सूत साइज की रोडी
कंक्रीट मिश्रण	1 सीमेंट : 1.5 रेत: 3 रोडी
सरिया	2.5 सूत (6mm) का सरिया दोनों दिशा में

कंक्रीट बीम

माप :	8" x 6", 150mm x 150mm) इस साइज की बीम को ऊपर दर्शाए गए सरिया के साथ 15' लम्बाई तक काम में लाया जा सकता है। इस से ज्यादा लंबाई की बीम बनाने के लिए इंजीनियर की सलाह अवश्य लें।
कच्ची सामग्री :	ओ पी सी 43 ग्रेड सीमेंट, मोटे दाने वाली रेत
कंक्रीट मिश्रण:	1 सीमेंट : 1.5 रेत: 3 रोडी
सरिया:	2.5 सूत और 4 सूत का सरिया ऊपर दिखाए चित्र के अनुसार

उत्पादन की प्रक्रिया (पट्टिका)

सरिया का जाल बनाएं

Ø 6mm सरिया काटे और सीधा करें

सरियों को साँचे के हिसाब से बांधें

सरिया का जाल साँचे में रखने के लिए तैयार

मिश्रण तैयार करें

4. सीमेंट, रेत, और गिट्टी को 1:1.5:3 के अनुपात में तोल लें
5. सूखी कच्ची सामग्री को मिलाकर उसका मिश्रण तैयार करें
6. अब मिश्रण में पानी मिलाकर एक समान मिश्रण तैयार करें

मोल्ड को तैयार करना

7. मोल्ड की सतहों के अंदर चिकनाई के लिए ब्रश से तेल लगाएं ।
8. स्ट्रेचर पर सरिया का जाल रखें और उसके ऊपर मोल्ड रखें ।
9. साँचे के साथ स्ट्रेचर को बंद करें और इसे वाइब्रेटर टेबल पर रखें

वाइब्रेटर सिर्फ उतना चलाएँ जितना कंक्रीट को साँचे के हर कोने में पहुँचने के लिए जरूरी हो

कंक्रीट डालें और वाइब्रेटर चलाएँ

सरियों को ढांचे के हिसाब से बांधें

बनाया गया जाल ढलाई के लिए तैयार

13. वाइब्रेटर को बंद करें। पट्टिका के सांचे को खोलें और इसे सुनिश्चित जगह रखें ।
14. तीस मिनट के बाद सांचे को खोलें और पट्टिका को सांचे से बाहर निकाल लें।
15. चौबीस घंटे के लिए स्टेचर पर पट्टिका को रखें ।

16. स्ट्रेचर से पट्टिका निकालें और इसे तराई की जगह पर रखें और 14 दिन तक तराई करें
17. छत बनाने के लिए अब ये इस्तेमाल करने के लिए तैयार है

उत्पादन की प्रक्रिया (जायस्ट)

एंड कवर को फिक्स करें और साँचे को जरूरत के अनुसार जोड़ें

साँचे में आवश्यकता अनुसार लंबाई में बुना हुआ सरिये को रखें

कंक्रीट को साँचे में डालें और वाइब्रेटर को चालू करें।

21. वाइब्रेटर को बंद करें। अगले दिन तक साँचे बीम को साँचे में ही रहने दें ।
22. अगले दिन, साँचे को खोलें और साइड कवर को हटा दें ।
23. स्ट्रेचर को साँचे सहित बने हुए बीम के साथ उठाकर समतल पर रख दें।

24. दूसरे दिन, बीम को साँचे से बाहर निकालें और यार्ड के सहारे उनको रखें।
25. 21 दिनों तक उन पर पानी का छिड़काव करें।
26. अब बीम छत पर लगाए जाने के लिए तैयार है।

क्या करें

मिश्रण में पानी मिलाने से पहले ही सूखे मिश्रण को मिलाएं ।

मिश्रण बनाने से पहले खल्ले माल का वजन कर लें

कंक्रीट को साँचे में भरने से पहले सतहों पर तेल लगा लें

डिजाइन के अनुसार सरिये से बने जैसिट डिजाइन का चुनाव करें

साँचे से बाहर निकालने के दौरान साँचे के किनारे को पकड़ कर ऊपर नीचे करें।

बीम बनाने से पहले वाइब्रेटिंग टेबल के साथ टेबल एक्सटेंशन फिट करें।

क्या न करें

- गैर जरूरी कच्ची सामग्री को मिश्रण में न मिलाएं
- कंक्रिट डालने के दौरान सांचे के कवर को न हटाए
- बिना इस्पात के सरिये के ढांचे के बिना कंक्रीट के मिश्रण को न डालें

गुणवत्ता जाँच

- सुनिश्चित करें कि कम से कम 14 दिनों के लिए पट्टिका और बीम के लिए उचित निगरानी हो। इस बात का ध्यान रखें कि इन पर पानी का छिड़काव किया जाता रहें या इनको गीले और नम बोरे से भी ढका जा सकता है।
- पट्टिका और बीम को स्थापित करने के बाद, पट्टिका और बीम के निर्माण में उनके सेंटर पर किसी प्रकार का भार नहीं पड़ना चाहिए। जब तक कि उस सांचे में इन–सीटू कंक्रीट डाला नहीं जाता है और कंक्रीट जम नहीं जाता है ।
- जहां तक संभव हो सके बीम को लंबवत स्थिति (सीधी) स्थिति में ही रखना चाहिए और परिवहन में भी उसको सीधा रखने की कोशिश करें। बीम को बीच में से न पकड़ कर उनके किनारों से (पकड़ना) संभालना चाहिए। सुनिश्चित करें कि जब तक छत पूरी तरह बन कर तैयार न हो जाए तब तक बीम को बीच में से सहारा मिलें ।

सामग्री और लेबर का विवरण

निम्नलिखित जानकारी 10' x 10' साइज के कमरे के लिए है।

सामग्री	मात्रा
कंक्रीट पट्टिका – 1'x5'	22
आर.सी.सी. बीम– 11'x6" लम्बाई	1
सीमेंट	6 बैग
रेत	9.5 घनफिट
गिट्टी – 6 मिमी.	7 घनफिट
गिट्टी – 10–20 मिमी.	12 घनफिट
6 मिमी. सरिया	20 किलो
10 मिमी. सरिया	3 किलो
कार्य करने वाले व्यक्ति	
मिस्त्री	1 व्यक्ति–दिन
मजदूर	8 व्यक्ति–दिन
बार बेंडर	1 व्यक्ति–दिन

Development Alternatives

Government of India
Department of Science & Technology
Ministry of Science & Technology

HESCO Himalayan Environmental Studies and Conservation

About Development Alternatives Group

Development Alternatives (DA) is a premier social enterprise with a global presence in the fields of green economic development, social equity and environmental management. It is credited with numerous technology and delivery system innovations that help create sustainable livelihoods in the developing world. DA focuses on empowering communities through strengthening people's institutions and facilitating their access to basic needs; enabling economic opportunities through skill development for green jobs and enterprise creation; and promoting low carbon pathways for development through natural resource management models and clean technology solutions.

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