Comprehensive *Disaster Risk Management*

Programme (UNDP/CDRMP)

Final Technical Report

Support to establish Technological Demonstration Center (TDC) in Gorkha District and Guideline for GI containment masonry for inclusion in NBC to contribute to the results of CDRMP

August 2016

Center of Resilient Development

Hariharbhawan, Pulchowk, Lalitpur, PO Box : 1681, Kathmandu, Nepal,

Phone No: +977 1 5010164, 015010032

Email: info@cordvia.org, Website: www.cordvia.org

Acknowledgement

We take this opportunity to express our gratitude to everyone who supported us throughout our efforts to establish Technological Demonstration Center (TDC) in Gorkha District and and prepare Guideline for GI containment masonry to support the reconstruction and recovery of earthquake hit rural community. We are thankful for their aspiring guidance, invaluably constructive criticism and friendly advice during the project work. We are sincerely grateful to them for sharing their truthful and illuminating views on a number of issues related to the CSEB and GI contained construction technologies.

We are highly indebted to CDRMP/ UNDP for entrusting CORD and the study team for construction of demonstration buildings for CSEB and GI contained technology. We appreciate the effort of Ms Pragya Pradhan, Programme Officer, UNDP/CDRMP for her continuous support and guidance for accomplishing various activities during the project implementation. We would like to express gratitude to Mr Vijay Singh, Assistant Country Director, Environment Energy Climate Change and Disaster Risk Management Unit, UNDP and Mr Ramraj Narsimhan, National Programme Manager, CDRMP, UNDP, Mr Vivek Rawal Shelter Expert UNDP for their continuous encouragements and guidance. Further, we would like to express our special gratitude to Mr Niraz Bhattarai, Principal Tri-Sakti Higher Secondary School Gorkha for providing space for the establishment of TDC. Besides he continuously supported the project. We express our heartfelt thanks to Mr Shyam Kishore Singh, SDE DUDBC Division Office Gorkha. We have put our best efforts in this project; however, it would not have been possible without the kind support and help of many individuals and organizations at local level. We would like to extend our sincere thanks to all of them.

Study Team

TDC at Gorkha

Abbreviations

CDRMP	: Community Disaster Risk Management Programme
CGI	: Corrugated Galvanized Iron
CoRD	: Center of Resilient Development
CSEB	: Compressed Stabilized Earthen Block
DDC	: District Development Council
DUDBC	: Department of Urban Development and Building Construction
GI	: Galvanized Iron
IEC	: Information Education and Communication
MOU	: Memorandum of Understanding
MOUD	: Ministry of Urban Development
NCPDP	: National Center for People's Action in Disaster Preparedness India
NPC	: National Planning Commission
ODR	: Owner Driven Construction
PCC	: Plain Cement Concrete
PDNA	: Post Disaster Need Assessment
RCC	: Reinforced Cement Concrete
SMC	: School Management Committee
TDC	: Technology Demonstration Center
UNDP	: United Nations Development Programme
VDCs	: Village Development Council

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1. Introduction

1.1. Background

The April 25 earthquake and its aftershocks specially of May 12, 2015 caused unprecedented destruction in Nepal with about 9,000 casualties, over 22,000 injuries along with complete destruction of more than half a million housing units and various level of damages to more than 250,000 buildings (PDNA, NPC 2015). The Government of Nepal has expressed its resolve to support the affected communities to reconstruct their houses with improved and affordable technologies for creating disaster resilient communities. The Nepal Earthquake Recovery and Reconstruction Policy has rightly focused on ensuring reconstruction of disaster resistant houses.

The Rapid Visual Damage Assessment revealed that more than 80 percent building collapsed are non engineered in rural areas constructed with traditional materials like earth, stone, bamboo, wood. This lead to building up of a common perception that houses built with 'traditional materials' like earth, bamboo or stone are weak, but the one built with 'modern materials' like cement, concrete and steel are strong. This perception is totally misplaced. The critical analysis of damage pattern and type along with their associated causes explicitly exhibit that poor quality of construction and inadequate structural details can make any building unsafe, even if it is made with concrete and steel. Understanding of disaster resistant construction technologies and practices can potentially equip the community to incorporate safety features in their new houses.

The PDNA 2015 outlines that in post disaster recovery; large amount of resources will be consumed in the reconstruction of houses. The socio economic and physical condition of nation does not allow to carry out reconstruction activities using modern engineering materials and technologies only. The recovery and reconstruction strategy of the government has rightly encouraged community participation and an owner-driven reconstruction (ODR) approach to build back better while also strengthening the local economy and ensuring the rehabilitation is equitable and inclusive. In context of Nepal, reconstruction is possible, feasible and resilient – but only when the community itself leads the process. This calls for not only creative funding and support but also innovative and affordable technological choices, information and timely technical advice. This requires facilitation and convincing demonstrations.

In this background the Government of Nepal, MOUD and DUDBC have planned to develop a mechanism to create awareness and technology transfer on disaster resilient building construction to the rural communities at district level with financial support from UNDP. In this context a concept of establishing a Technology Demonstration Center (TDC) has evolved.

1.2. Concept of Technology Demonstration Center

A **Technology Demonstration Centre** is conceived as a community space/resource centre to demonstrate various types of materials as well as construction technologies. Choices appropriate for different communities and households result in a large basket of material and technology options and it is imperative to facilitate disaster resistant construction for each option. Therefore, Technology Demonstration Centre will have prototypes designs constructed with different materials and technologies. It aims to highlight details and features to improve disaster resistance of the buildings using various different materials and technologies based on their relevance and prevalence in the district. The focus is also on artisan centred technologies as artisans are the guide and service providers for rural households. This centre is meant for masons, carpenters, contractors, homeowners engaged in construction of one or two storey dwellings. The TDC is also open for technical personnel working in the local bodies (municipalities/VDCs) who are involved in guiding the local level construction. It will provide guidance on good construction aspects as well as essential disaster resistant features that must be adhered to, when constructing with the given materials to reduce the risk and threat to life of inhabitants. The learner/observer who intends to start construction afresh can make an informed decision on material, technology and disaster resistant details to use, from the repository of prototypes demonstrated. This centre can serve the following two key functions.

i) **Facilitating Informed Choice**:

For the reconstruction of houses, it is necessary that house owners make informed choice from a large basket of options available to them based on different materials, costing, and availability of skills. At TDC, home owners can see the houses built with different material and technology options along with the cost.

ii) **Education, Training and Capacity Building:**

The TDC will evolve as resource center where trainee masons, carpenters and house owners can make an exposure visit.

The TDC can be expanded to accommodate other prototypes or simply the posters of different construction technologies could be displayed in the center. Besides the CBSE an GI contained masonry structure, the TDC can demonstrate the following technology option demonstrations. This list is only indicative.

1. Random rubble stone masonry in mud mortar with RCC reinforcement
2. Load bearing reinforced brick masonry
3. Compressed Stabilized Earth construction

4. GI wire reinforced stone masonry with timber/ bamboo seismic bands
5. Other innovative technologies like bamboo based construction, etc.

Besides the TDC can display all the 17 types of design suggested by DUDBC through posters

1.3. Objective

The overall objective of the endeavor is to enable the local communities to take informed decisions for reconstruction of their houses and communities with various earthquake resistant technological options compatible to their socio economic conditions and traditions. The specific objectives are:

- Establish a Technological Demonstration Center in the district displaying various earthquake resistant technologies for local rural housing/building construction
- Construct two earthquake resistant demonstration buildings and components compatible with rural construction priority
- support formulation of a guideline for GI contained stone masonry for its inclusion into the national building code

1.4. Methodology

A collaborative approach has been adopted where CORD collaborated with UNDP and National Center for People's Action in Disaster Preparedness (NCPDP) India for establishment of the TDC in Gorkha. The TDC is tied with DUDBC division office, School Resource Center and DDC Gorkha so that more people could have detailed and easy access to resources available in the TDC. For making TDC, the following steps were taken.

1. Selection of Site for TDC in consultation with DUDBC and local district officials.
2. Prepare site plan
3. Identifying the construction technology that have been demonstrated
4. Construction of two prototypes buildings
5. Development of IEC materials and installation of information panels, poster, manual, process handbook and photographic exhibition for display and training
6. Deployment of Dedicated Engineer
7. Formulation of a guideline for GI contained stone masonry and Demonstration of Technology in the field

2. Selection of Site

Selection of site for establishment of the Technology Demonstration Center is crucial as it sets the tone for its purposeful use for next 5 years during which the reconstruction of houses will be carried out. Accordingly a set of criteria were set up, discussed with UNDP. The basic criteria were:

- The site should be located in district head quarter as it is the most visited settlement within the district where local residents pay visit for numerous administrative, development and business works.
- The site should be within or near to DUDBC division office premises. If not then it should be located near the DDC premises
- The site should be under the ownership of government institution and sign an MOU that the site will be available for next 3 yrs.
- The site should have uninterrupted access to population

The criteria were discussed and agreed with UNPD. With this background, the study team visited Gorkha District head quarter; however it was not possible to zero down the site in first visit. Again the team along with professional from NCPDP India visited Gorkha and consulted with DUDBC division office and DDC office. The concept of establishment of TDC was explained and a presentation was carried out on GI contained wire technology and CSEB. They appreciated the concept and acknowledged that such technologies can only make the reconstruction reality. However the DUDBC division office officials and DDC officials expressed their inability to provide the space as they themselves are not having the enough space. The local development officer of DDC suggested to visit the district education office as the centrally located school has such land and can only provide.

The district education officer when approached asked us to talk to School Management Committee which can take the decision. The SMC (School Management Committee) chaired by Head Master (Principal) showed their keen interest with few reservations. As the site did not fulfill all the criteria, the site could not be selected. The issue delayed the project by more than two months as appropriate site could not be zeroed down.

In mid march, after rigorous discussion, the school site was chosen jointly by the study team and officials from UNDP/CDRMP. The study team organized a meeting with SMC and a MOU was signed (Annex 1). The school asked us to change the size of the room so that it could be used later on for certain activities of school and prepare a master plan of the school premised. We all agreed and MOU was signed.

3. Survey and Mapping

The school premises was surveyed and master plan of area depicting different structures was prepared and submitted to the school management committee as agreed in the MOU with the school.

4. Design Drawing and Estimate of GI Contained and CBSE Buildings

Architectural Design and drawings and structural details of GI contained stone masonry with mud mortar was prepared and submitted by NCDPP India while that of CSEB was prepared by CoRD (Annex 2A and 2B respectively).

5. Construction of GI Contained Building

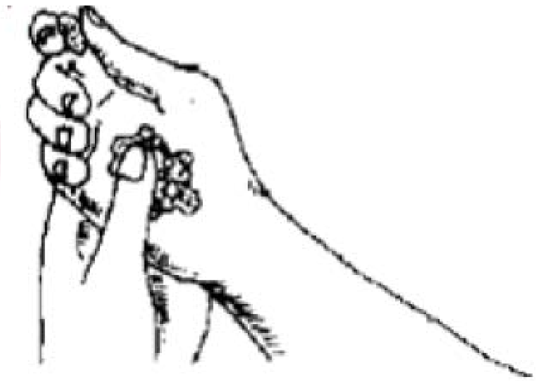
The construction process and technical considerations for GI contained wire is attached in Annex 3 (Technical Guideline for making GI contained stone masonry).

6. Construction of CSEB Building

The construction of CSEB starts with selection of tools and soil for production of bricks at local level. The tools required are locally available tools used in building construction except the 20 ton manual soil compressor machine.

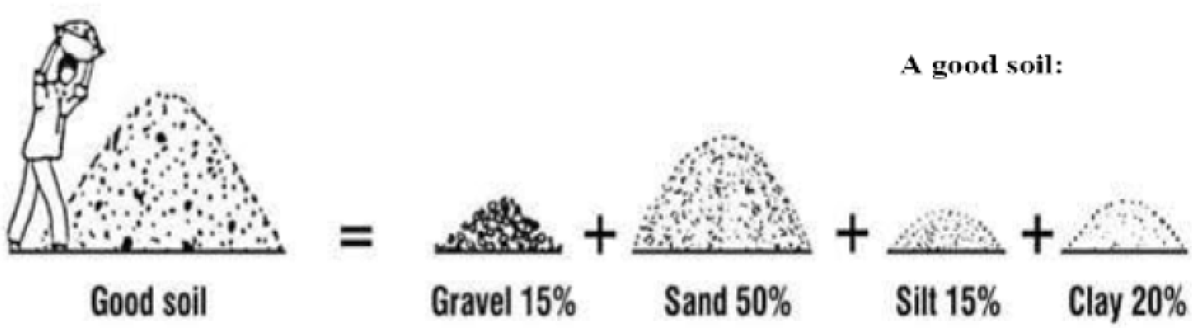
6.1. Selection of Soil

A good soil for making CSEB block needs to have 50 percent sand as depicted in the figure above. In Gorkha soil was clayee nature and hence extra sand was added for proper proportion. 5 % cement has been used as stabilizer. Mixing brings the stabilizer and soil into direct contact which enhances the chemical reaction and cementing action. It also reduces the risk of uneven production of low quality blocks. Various types and sizes of mixing equipment are available on the market. All soils consist of disintegrated rock, decomposed organic matter and soluble mineral salts. Soil types are graded according to particle size using a system of classification widely used in civil engineering.



6.2. Material Collection

Materials required for casting of bricks in situ are collected and stored at site. The materials required include sand, cement, iron bars and soil dug after removing the top layer. The soil lumps are broken to make it uniform such that it could pass through the 5mm sieve.



6.3. Soil Test

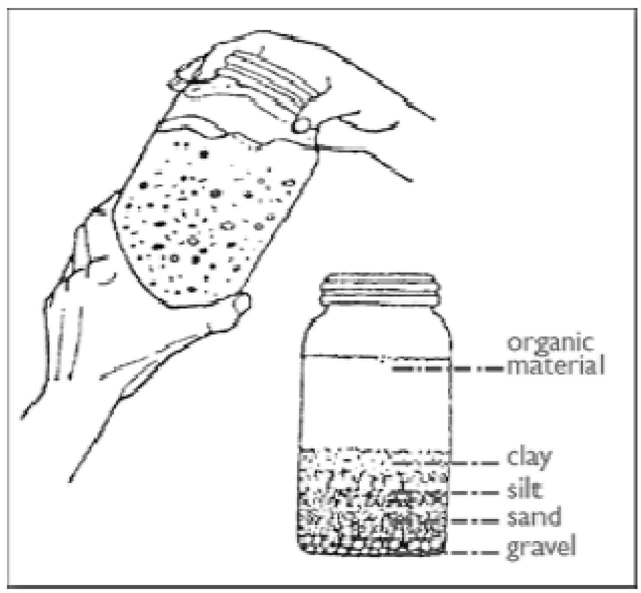
Simple tests could be done at site to find out the type of soil. It will give an idea whether sand need to be mixed or not. The tests include

Touch test

After removing the largest grains, crumble the soil rubbing it between the fingers and the palm The soil is sandy if a rough sensation is felt and has no cohesion when moist. The soil is silty if it gives a lightly rough sensation and is moderately cohesive when moistened. The soil is clayed, if, when dried, contains lumps or concretions which resist crushing and if becomes plastic when moistened.

Sedimentation Test

To obtain a more precise idea of the nature of each soil fraction, a simplified sedimentation test can be carried out in the field. The apparatus required is a transparent cylindrical glass bottle with a flat bottom and a capacity of at liter with a neck wide enough to get a hand in and a lid to allow for shaking.



Fill the bottle to one-third with clean water. Add approximately the same volume of dry soil passed through a 6mm sieve and add a teaspoonful of common salt. Firmly close the lid of the bottle and shake until the soil and water are well mixed. Allow the bottle to stand on a flat surface for about half an hour. Shake the bottle again for two minutes and stand on level surface for a further 45 minutes until the water particles fall more slowly and as a result, it will get deposited on top of the larger size particles. Two or three layers will emerge, with the lowest layer containing fine gravel, the central layer containing the sand fraction. The depth of each layer is measured and hence percentages, of each fraction can be determined.

Other simple tests like adhesion test, washing tests etc could also be carried out at the site to understand the nature of soil and requirement of sand.

6.4. Breaking and Sieving of Soil

In order to obtain a uniform mix of the mineral components, water and stabilizer, lumps more than 200mm in diameter after excavation must be broken up. Grains with a homogeneous structure, such as gravel and stones, must be left intact, and those having a composite structure (clay binder) broken up so that at least 50 percent of the grains are less than 5mm in diameter. The soil must be dry as wet soil can only be handled by certain mechanized systems.

a. Grinding followed by screening

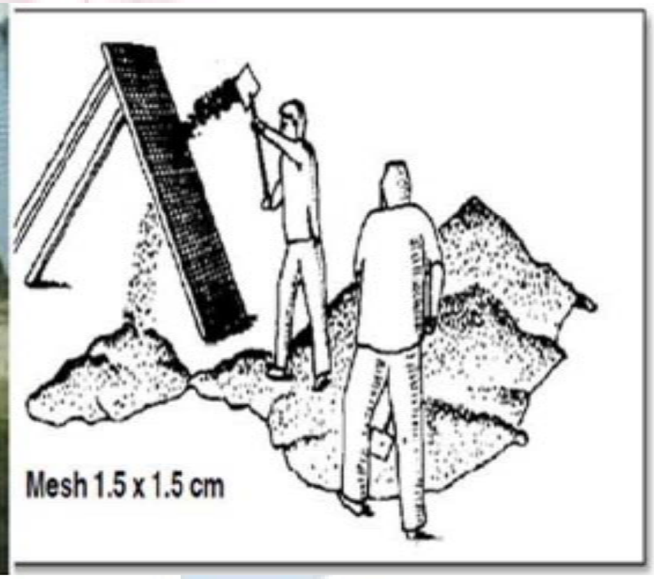
The material is pressed between two surfaces - a rather inefficient and tedious process in which bigger stones are broken up, however, only simple machinery is required. The broken up lumps of soil are then passed through a screen.

b. Pulverization of soil

The material is hit with great force so it disintegrates. The machinery required is complex but performs satisfactorily. At the delivery end, any large pieces left can be removed by means of screen.

c. Sieving

Soil contains various sizes of grain, from very fine dust up to pieces that are still too large for use in block production. The oversized material should be removed by sieving, either using a built-in sieve, as with the pendulum crusher, or as a separate operation. The simplest sieving device is a screen made from a wire mesh, nailed to a supporting wooden frame and inclined



at approximately 45^o to the ground. The material is thrown against the screen, fine material passes through and the coarse, oversized material runs down the front. Alternatively, the screen can be suspended horizontally from a tree or over a pit. The latter method is only suitable in the case where most material can pass through easily otherwise too much coarse material is collected, and the screen becomes blocked and needs frequent emptying.

6.5. Proportioning

Before starting production, tests should be performed to establish the right proportion of soil, stabilizer and water for the production of good quality blocks. The proportions of these materials and water should then be used throughout the production process. To ensure uniformity in the compressed stabilized earth blocks produced, the weight or volume of each material used in the block making process should be measured at the same physical state for subsequent batches of blocks. The volume of soil or stabilizer should ideally be measured in dry or slightly damp conditions. After establishing the exact proportion required of each material, it is advisable to build a measuring device for each material. The dimensions of each measuring box should be such that their content, when full, is equivalent to the proportion which should be mixed with other materials measured in other gauge boxes.

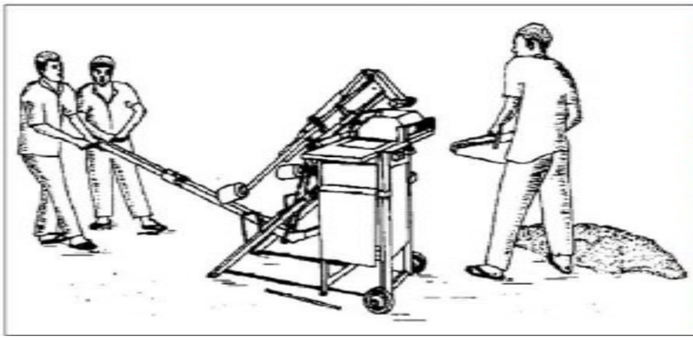
Alternatively, a simple gauge box may be used for all materials. In this case, the amount of material for the production of a given batch of blocks may be measured by filling and emptying the gauge box a number of times for each separate material. For example, a batch of blocks may require ten gauge boxes of soil for one gauge box of stabilizer. Water may be measured in a small tank or container. It is advisable to mix enough materials to allow the block-making machine to operate for approximately one hour. Thus, the volume of the mixed material will depend on the hourly output of the block making equipment.

6.6. Mixing

In order to produce good quality blocks, it is very important that mixing be as thorough as possible. Dry materials should be mixed first until they are of uniform color, then water is added and mixing continued until a homogeneous mix is obtained. Mixing can be performed by hand on a hard surface, with spades, hoes, or shovels. It is much better to add a little water at a time, sprinkled over the top of the mix from a watering can with a rose spray on the nozzle. The wet mix should be turned over many times with a spade or other suitable tool. A little more water may then be added, and the whole mixture turned over again. This process should be repeated until all the water has been mixed in. A concrete mixer, even if available, will not be useful for mixing the wet soil, since the latter will tend to stick on the sides of the rotating drum. If machinery is to be used for mixing, it should have paddles or blades that move separately from the container. Hand-mixing methods are often more satisfactory, more efficient and cheaper than mechanical mixing, and are less likely to produce small balls of soil that are troublesome at the block moulding stage.

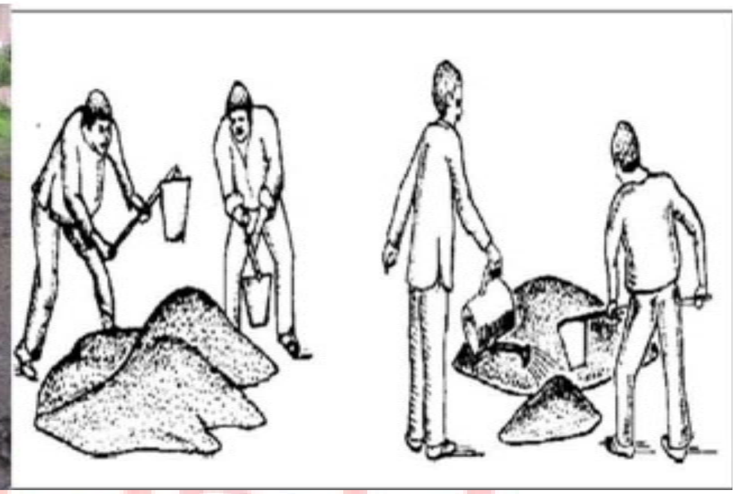
- Pour in order, soil, sand and stabilizer
- First Mix dry , 2 times

- Add water and mix wet, 2 times




6.7. Moulding of CSEB

To manufacture blocks of uniform size and density, special precautions must be taken to mould with the same amount of mix for each compaction by using a small wooden box as a measuring device. To facilitate development of the pressed blocks and to ensure good neat surfaces it is advisable to moisten the internal faces of the machine which can be applied with a rag, brush or spray. Aurum press 3000 is for moulding the CSEB

6.8. Curing of CSEB

To achieve maximum strength, compressed stabilized earth blocks need a period of damp curing, where they are kept moist. If the block is left exposed to hot dry weather conditions, the surface material will lose its moisture and the clay particles tend to surface cracks on the block faces. In practice, various methods are used to ensure proper curing. Such methods include the use of plastic bags, grass, leaves, etc. to prevent moisture from escaping. The required duration of curing stabilizer is used. **With cement stabilization, it is recommended to cure blocks for a minimum of three weeks.** The curing period for lime stabilization should be at least four weeks. Compressed stabilized earth blocks should be fully cured and dry before being used for construction.

Golden Rule

- The pile must remain covered 2 days with a plastic sheet

- Stacking the fresh block
- Cover immediately every row with a plastic sheet.


6.9. Quality Control

Compressed stabilized earth building blocks are usually larger in size than traditional burnt bricks. A typical block size is 240 x 140 x 90mm. The exact amount of stabilizer necessary must be established for any particular project. The fraction of cement usually varies between 5% to 8% by weight.

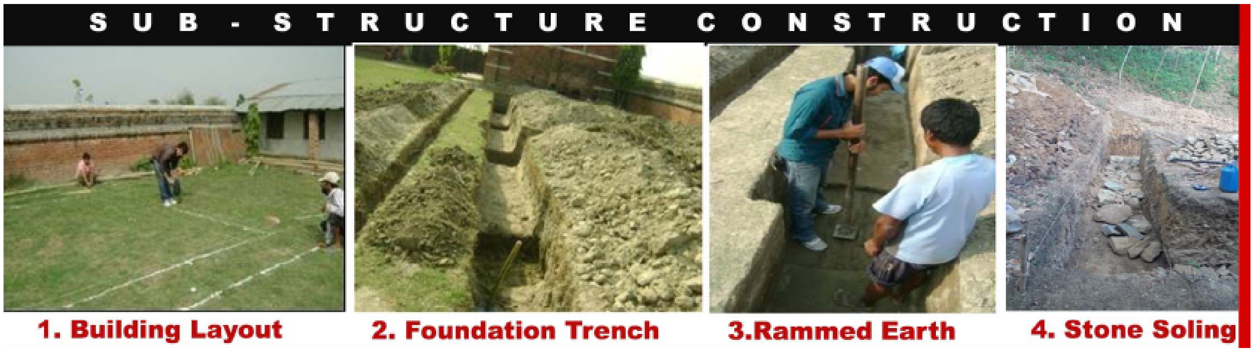
Golden rules

- To create a joyful atmosphere where everybody is conscious of the quality required and check the blocks.
- Check the production at every stage
- Check the quality of the compression with the pocket penetrometre, always for the first block of every mix.
- Check the height with the block height gauge, always for the first block of every mix.
- Follow the production daily. Record the output and dates...
- Check weekly or monthly, the production with the field block tester (after 28 days).

7. Construction of CSEB Building

Lay out and Sub Structure Construction

Construction of CSEB building is similar to any other building construction using the simple brick. It starts with lay out of the building on the ground followed by trench digging, ramming of earth, stone soling and PCC on which the foundation is laid out. As per the design drawing, the foundation is also made up of stabilized soil. In some cases it could be made up of stone masonry too.



Super Structure Construction

This is characterized by construction of wall, positioning of door and windows, and construction of will and lintel bands. The vertical ties and the ring beams consist of reinforcement of 2-10mm diameter bars whereas the lintel consists of reinforcement of 2-12mm diameter bars owing to more flexure that it has to bear from the above wall. The bands, at corners and T-joints, consist of extra bars of 10mm extending 50cm along each adjacent wall for additional reinforcement. The stirrups of 8mm bars are arranged in all case at spacing of 25cm.

All courses should be bound by cement stabilized earth mortar 1 cement: 1 soil: 3 sand. It should be plastic and not too liquid. The soil should not have more than 20-25 % of clay. All joints, horizontally and vertically, are 5 mm thick. Note a cement sand mortar (i.e. 1: 4) will have a very low workability as the mortar thickness is only 5mm. **The blocks must be soaked before being laid and a well-laid block is impossible to remove with one hand because it sticks well to the cement sand mortar.** All the holes, with or without reinforcement, and all ring beams, are filled with plain cement concrete 1: 1.5: 3. The plasticity of the concrete for the holes is rather fluid, but not liquid. It should flow well in the holes without being a soup. It is essential to compress very well the concrete with a steel rod.

9. Door Installation

10. U-Block for Sill Band

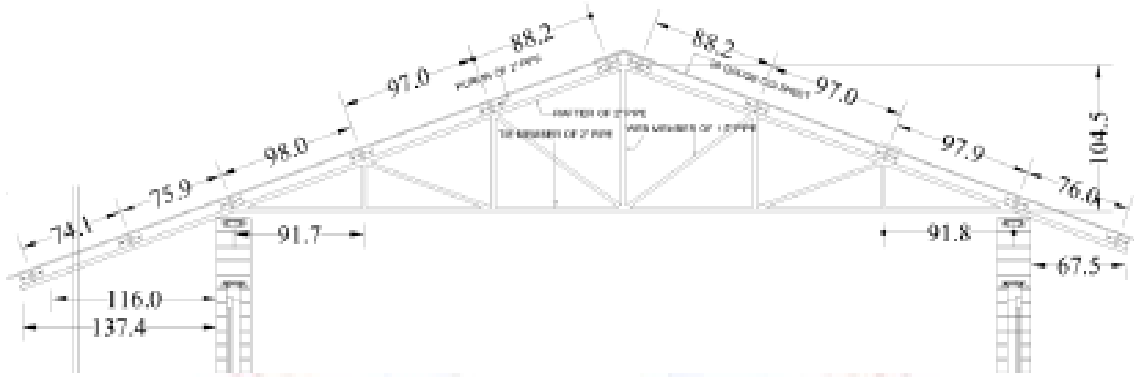
11. Concreting of Sill Band

12. Window Installation

13. Reinforcement for Lintel

14. Full Model Structure

CGI Sheet Truss Roof
Lattice steel trusses are fabricated from **tubular steel sections** that are cut, mitered and welded. CGI sheet roof as we all know has advantages like maintenance free, leakage free, fire resistance etc. But it has many defects too. It is extremely hot during summer and scorching cold during winter. Hence false ceiling are provided to maintain indoor comfort level.



8. Earthquake Safety Features

Nepal faces a high frequency of seismic hazards. However, it can be well seen that even the basic norms for its prevention has not been implemented in the built structures. Through this project, the criteria that have to be taken into earthquake proof building are highlighted so as to create an awareness among the local people regarding their safety in the buildings.

The five horizontal ring beams are tied together by the vertical ties. Together the horizontal and vertical ties make a skeleton like network of reinforcement. The idea is that the metal reinforcements bring ductility (flexibility) to the building and the building is able to absorb a lot of energy before a major damage. In the event of an earth quake not collapse and if it has to collapse then it should give enough time to the people to leave thebuilding.

Following seven features are considered for the CSEB Project as the earthquake features:

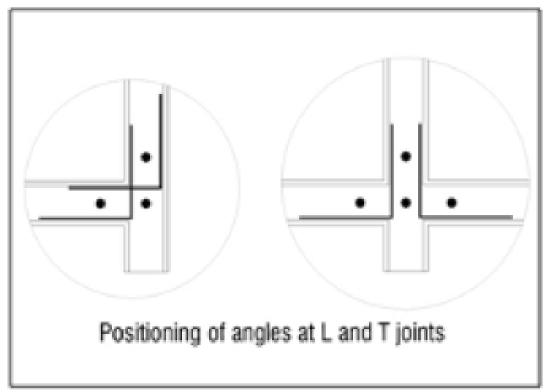
Building Shape
The building is proposed as rectangular in shape which is the best shapes for earthquake resistant buildings due to regular shapes and perfectly symmetrical in two axes. In this case the centers of gravity and rigidity will be the same and therefore the building is safe
Ductility
Masonry components are most of the time brittle ones. Reinforcements are added to make a structure more ductile with these brittle materials. Ring beams at various levels, which are linked together with vertical ties, will reinforce the structure very well and make it ductile.
Rigidity Distribution
The centre of gravity of the plan lies on the centre of rigidity of the vertical masses. This would avoid torsion of the building. The vertical rigidity of the building is well distributed.

Simplicity
Simplicity in the ornamentation is the best approach. Large cantilevered projections, cladding materials, etc are dangerous during earthquakes. They are avoided.

Foundation
Certain types of foundations are more susceptible to damage than others. Isolated footing of columns can easily be subjected to differential settlement, particularly when they rest on soft soils. Mixed foundations in the same building are also not suitable. What works best in most of cases is trench foundation.

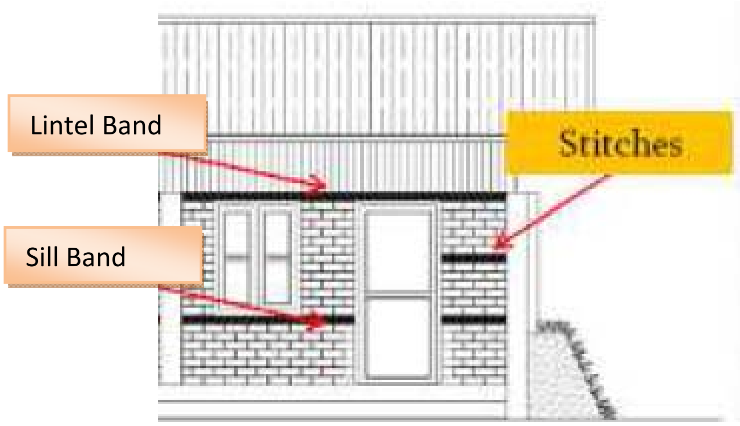
Openings
Doors and windows reduce the lateral resistance of walls to shear. Hence, they should preferably be small and rather centrally located. The specification mentioned in IS 4326: 1993 are followed.

Structural Integrity (Box Action)
Past earthquakes have shown that damage to masonry buildings is significantly reduced when building components are well connected and the building vibrates like a monolith box. There is a need to provide additional elements to tie the walls together and ensure acceptable seismic performance. Structural integrity of a building can be achieved by developing a box action by ensuring good connections between all building components like foundations, walls, floors, and roof.



Connection betwee enn walls

Positioning of aangles at L and T joints



Key requirements for the structural integrity in a masonry building are:
• Stiff foundation
• Good connection between wall and foundation
• Good connection at wall corners
• Ring beam
• Vertical ties
• Small openings
• Good connection between wall and roof

9. IEC Material

The IEC materials to disseminate the information to different stakeholders specially the local communities who will be constructing their houses and even to engineers deployed by DUDBC have been prepared. The material could be used by any agencies that will be delivering training and other services for construction of housing unit can use the material to understand and use the technology. The major IEC material include

- Video of construction process
- Poster depicting the technology
- Leaflet introducing the technology

Further information could be collected from DUDBC engineer or can directly contact to CORD office in Kathmandu.
The solar system along with audio visual arrangements will be in place to demonstrate the technology.

10.Cost of Construction

The cost of construction of GI contained stone masonry with mud mortar is about 15% higher than the stone masonry in mud mortar while that of CSEB is about 10 percent less than that of regular brick masonry works. In this context the construction is affordable with all features of earthquake resistant technology.

11.CONCLUSION

After Gorkha Earthquake Nepal is under tremendous pressure for rapid reconstruction of more than 5000 houses in rural areas where earth and labor could be abundantly found. Nepal with its economic condition and level of infrastructure in earthquake affected districts, it is not possible to use modern engineering technology and material for reconstruction works. In this context new innovative technology using local resources can be handy. In this regard the GI contained stone masonry and CSEB provide a possible viable solution. This cost effective technique applied on a large scale, is expected to generate local employment and save the country millions of dollars worth of foreign currency. Besides the environmentally clean CSEB technique can replace fired bricks and save the nation‘s precious forest resources as well as carbon emissions

Annex 1: MOU signed between School and CORD

श्री शक्तिउच्च माध्यमिक बिद्यालय गोरखा

तथा

उत्थानशील विकास केन्द (CoRD)

का

बीच भूकम्प प्रतिरोधी प्रर्दशनी भवन निर्माण गर्नका लागी गरिएको

सम्झौता - पत्र

नेपालमा सबै खालका बहुप्रकोपहरुको जोखिम संभावना रहेको तथ्यलाई नर्कान सकिदैन । उत्पत्तिकालदेखिको ईतिहांसलाई हेर्ने हो भने नेपाल भूकम्पीय जोखिम को समेत संकटासन्नता क्षेत्रमा रहेको छ । बिनासकारी भूकम्प तथा जोखिमपूर्ण भौतिक संरचनाका कारणले यहा गत बैशाख १२ गते आएको बिनासकारी, महाभूकम्प का कारणहरुबाट १४४४१ बिद्यालय का कक्षाकोठाहरुमा पुर्ण रुपमा क्षति पुर्याको छ । भबिष्यमा हुनसक्ने अन्य प्राकृतिक बिपद्हरुका लागी र संभावीत जोखिमलाई मनन् गरि बिद्यालयका संरचनाहरुको पुननिमार्ण तथा बिपद् उत्थानशिल बिद्यालय भवनहरुको निमार्ण गरिनु पर्ने टड्कारो अवस्था हाम्रो सामु रहिआएको छ । नेपालको भौगोलिक,,भौगर्भिक तथा पारिस्थितिक बनावटका कारणले अन्य पानीजन्य,तथा नितान्त प्राकृति जन्य प्रकोपको समेत जोखिमयूक्त क्षेत्रमा अवस्थीत मुलुक रहेको कुरा बिगतमा भएका बिनासकारी प्रकोपहरुको ईतिहांसबाट प्रमाणीत भईसकेको छ । नेपालमा हरितवाताबरणीयमैत्री तथा भूकम्पीय जोखिमता न्यूनिकरणको क्षेत्रमा लामो समयसम्म प्रबिधिको बिकास तथा निर्माण जगतको अग्रणीसंस्थाको रुपमा रहेको उत्थानशील विकास केन्द्रले पनि बिविधखालको प्रविधिको विकास तथा प्रसार, तालिम तथा जनचेतना अभिवृद्धिको माध्यमद्वारा नेपालको सम्पूर्ण समुदायलाई विपद्बाट सुरक्षित एवं उत्थानशील बनाउने लक्ष्य सहित विभिन्न कार्यक्रमहरु संचालन गर्दै आएको छ । मानविय संबेदनाका बिषयमा दुबै संस्थाका बिचमा प्रकोप प्रभावीतहरुका लागी हातेमालो गरेर बिकास निर्माणका क्षेत्रमा साझा अवधारण तयार गरि समान उद्देश्य प्राप्तीका लागी एकिकृत प्रयास गर्न सकिएको खण्डमा प्रभावीतहरु प्रतिको सहजै शिक्षा पाउने अधिकार सुनिश्चित तथा बिपद् उत्थानशिल बिद्यालयको बिकास हुने तथ्यलाई महशूस गरी यो सम्झौता-पत्र तयार गरिएको हो ।

प्रधानाध्यापक
श्री शक्ति उच्च माध्यमिक विद्यालय
पाटेचौर-३, गोरखा

सहमतिका आधारहरु :

यहा उल्लेख भएका सम्झौता पत्रमा निम्नलिखित आधारहरु रहने छन्।

१. भूकम्प प्रतिरोधी प्रर्दशनि बिद्यालय निर्माणबाट गोरखा जिल्लामा अब बन्ने भौतिक संरचनाहरु नमुनामा देखाईएको जस्तै भूकम्प प्रतिरोधी निर्माण हुने दुबै संस्थाको साझा उदेश्य तथा लक्ष्य रहने छ।

२. दुवै संस्थाहरुमा रहेका साधन स्रोतहरुको संयूक्त तथा सहभागीमुलक परिचालनबाट कामको प्रभावकारीतामा अभिबृद्धि गरिने छ।

३. आपसी तथा सहभागीतात्मक रुपमा पारस्पारीक आदान प्रदानको मान्यता रहने छ।

४. साझेदारीतामा संचालन भएका क्रियाकलापहरुको एक आपसमा वकालत गरिने छ।

५. समान उद्धेश्य प्राप्तीबाट संचालन भएका कार्यक्रमहरुको समान लक्ष्यसहितको परिपुरका रुपमा लिईने छ।

६. संचालन भएका कार्यक्रमहरुलाई एउटै अवधारणा बनाई एकरुपता दिईने छ।

उत्थानशिल बिकास केन्द्रद्धारा गरिने कार्यहरु

- स्थानिय निर्माण सामाग्री तथा न्यून रुपमा बजारबाट खरिद गरि स्थानिय ,सिप,दक्षता र सुन्दरतालाई समाबेस गरी भूकम्प प्रतिरोधी प्रर्दशनी बिद्यालय भवन निर्माण गरिने छ।
- भूकम्प प्रतिरोधी प्रर्दशनी बिद्यालय भवन निर्माणको नाप नक्शा तथा डिजाईन यसै संझौतामा संलग्न गरिएको Drawing अनुसार निर्माण गरिने छ।
- भूकम्प प्रतिरोधी प्रर्दशनी बिद्यालय भवन निर्माण संहिताबारे जनचेतना अभिवृद्धि तथा भूकम्प प्रतिरोधात्मक भवन निर्माण प्रविधिको प्रचार प्रसार गर्ने।
- भूकम्प प्रतिरोधात्मक बिद्यालय भवन निर्माणका लागि आवश्यक जनशक्तिको विकास तथा विद्यमान जनशक्तिको क्षमता अभिवृद्धि गर्ने।
- स्थानीय निकायहरुमा भूकम्पीय बिदालय भवन निर्माण संहिता लागू गर्न संयुक्त प्रयास तथा क्षमताको अभिबृद्धि गर्ने ।
- भूकम्पीय जोखिममा रहेका बिद्यालयका भौतिक संरचनाहरुको संभावीत जोखिमतालाई न्यून गर्नका लागी त्यस्ता संरचनाहरुको निर्माण गर्ने तौर तरिकाहरुको प्रचार प्रसार गर्ने।
- शैक्षिक सुचनामुलक सामाग्री तथा प्रबिधियूक्त डिजाईन मार्फत विद्यालय तथा समुदायको क्षमतामा अभिबृद्धि हुने खालका सामाग्रीहरुको प्रचार प्रसार गर्ने।
- भूकम्प प्रतिरोधात्मक प्रर्दशनी बिद्यालय भवन निर्माणका लागि आवश्यक जनशक्ति तथा निर्माण सामाग्रीहरुको ब्यबस्था खरिद तथा बजारको अबस्था बारेमा संस्थाले नै ब्यबस्था गर्ने छ।
- श्री शक्ति उच्च मा.वि. को गुरुयोजना (Master Plan) को Flex Print तथा Computer Design सहितको तयार गरी विद्यालयलाई हस्तान्तरण गरिने छ।
- प्रदर्शनी स्थल कोठामा जडान गरिएका प्रचार, प्रसारका सामाग्रीहरु (पाठ्यपुस्तक, पर्चा पम्पलेट, कम्प्युटर, टेलिभिजन तथा अन्य सम्पूर्ण सामाग्रीहरु) विद्यालयलाई हस्तान्तरण गरिने छ।

10/29

श्री शक्ति उच्च माबी द्धारा पुर्‍याउनु पर्ने सहयोगका क्षेत्रहरु:

माथी उल्लिखित उद्देश्य परिपूर्तिका लाथि बिद्यालयद्धारा प्रर्दशनि बिद्यालय भवन निर्माण कार्यका पुर्‍याउनु पर्ने सहयोगका क्षेत्रहरु तपसिल बमोजिमा रहेका छन् ।

भूकम्पीय सुरक्षा अभिवृद्धिका लागि संयुक्त वा एकल रुपमा संचालन गर्ने कार्यक्रमहरुमा एक अर्काको सहभागिता सुनिश्चित गर्ने ।

- बिद्यालयले आफ्नो बिद्यालयको हाता भित्रमा नाप नक्शा तथा डिजाईन अनुरुपको भूकम्प प्रतिरोधी प्रर्दशनी भवन निर्माण का लागी चाहिने जग्गा उपलब्ध गराउनु पर्ने छ ।
- बिद्यालयले आफ्नो बिद्यालयको हाता भित्रमा नाप नक्शा तथा डिजाईन अनुरुपको भूकम्प प्रतिरोधी प्रर्दशनी भवन निर्माण का लागी चाहिने आवश्यक सल्लाहा तथा सुझाबको लागी संस्थाद्धारा माग भएमा बिद्यालयले सो लागी खटाईएको ब्यक्तिबाट मात्र सल्लाहा सुझाब लिने छ तथा उपलब्ध गराउनु पर्ने छ ।
- ३ वर्षको लागी भूकम्प प्रतिरोधी प्रर्दशनी भवन समुदायलाई अवलोकन गर्न दिनुपर्ने छ ।
- ३ वर्ष पछी भूकम्प प्रतिरोधी प्रर्दशनी भवनको स्वामित्वो बिद्यालयले लिनुपर्ने छ ।
- आवश्यकता अनुसार आवश्यकीय शैक्षिक सहयोगको आदन प्रदान गर्ने ।

माथी उल्लेखीत कार्यहरु गर्नका लागी दुवै संस्थाले गर्ने गतिविधिहरुलाई अझै बढी प्रभावकारी बनाउन तथा तिनीहरुलाई उजागर गर्न एक अर्कालाई सघाउ पुर्‍याउनेछ ।

उपरोक्त कार्यहरुको कार्यान्वयन गर्दा एक अर्कालाई सु-सूचित गराउने र संलग्नता कायम राख्ने वातावरण सृजना गर्नु दुवै पक्षको कर्तव्य हुनेछ । यो सम्झौता पत्र दुवै पक्षको परस्परको समझदारीका रुपमा पालना गर्ने प्रतिबद्धता जाहेर गर्दै यो सम्झौतापत्रमा दुबै पक्षका तर्फबाट हस्ताक्षर गरिएको छ ।

श्री शक्ति उच्च माध्यमिक बिद्यालयका तर्फ बाट

१०/२४

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(श्री निरज बाबु भट्टराई)

प्रधानाध्यापक

प्रधानाध्यापक
श्री शक्ति उच्च माध्यमिक विद्यालय
पाटेचौर-३, गोरखा

उत्थानशील विकास केन्द्र
तर्फबाट

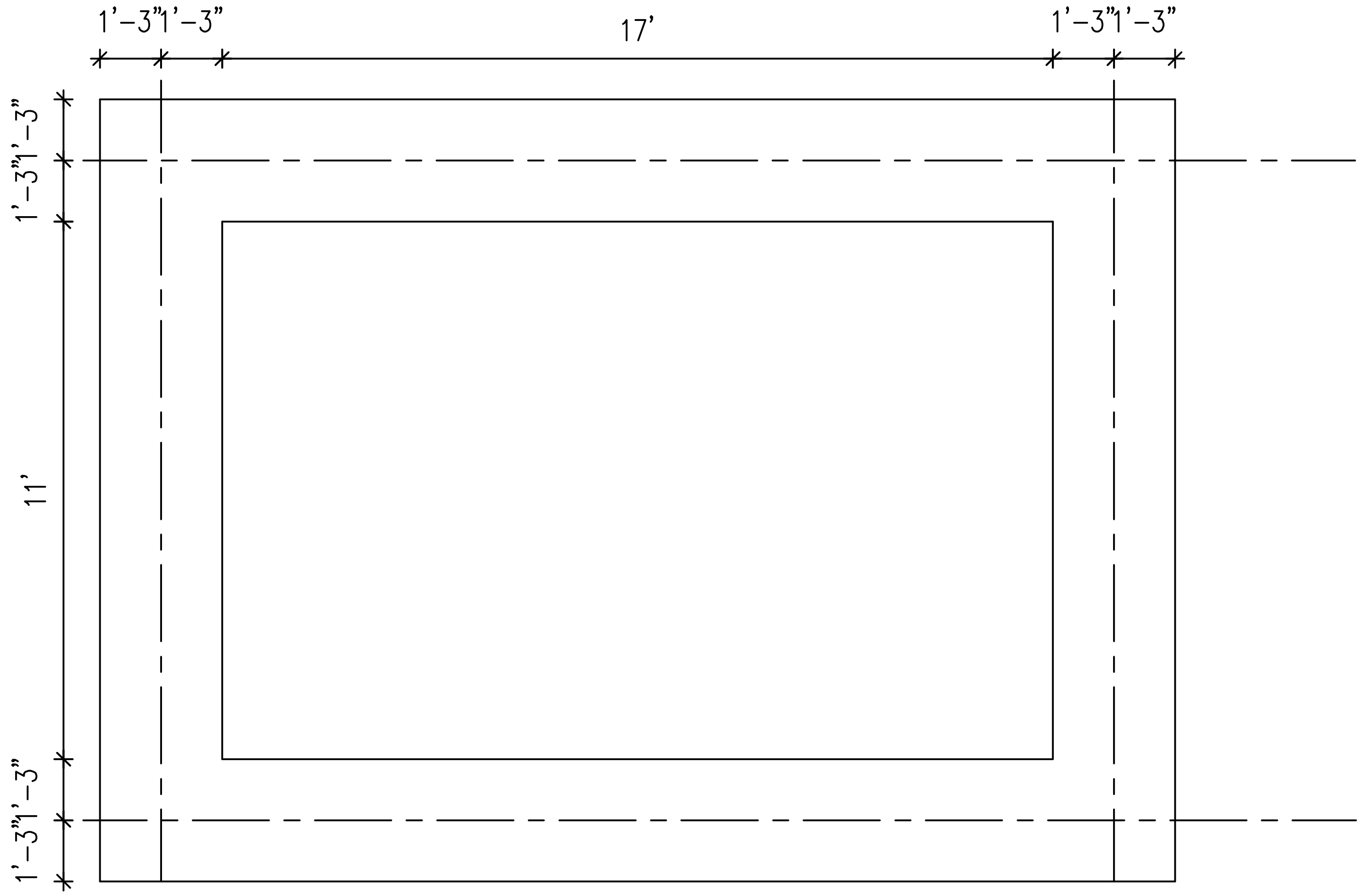
....

(श्री हरिदर्शन श्रेष्ठ)

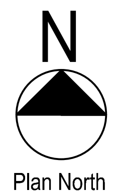
अध्यक्ष

मिति : २०७२ साल माघ २४ गते रोज १ शुभम् ।

Annex 2A: Design and Drawings for GI contained construction



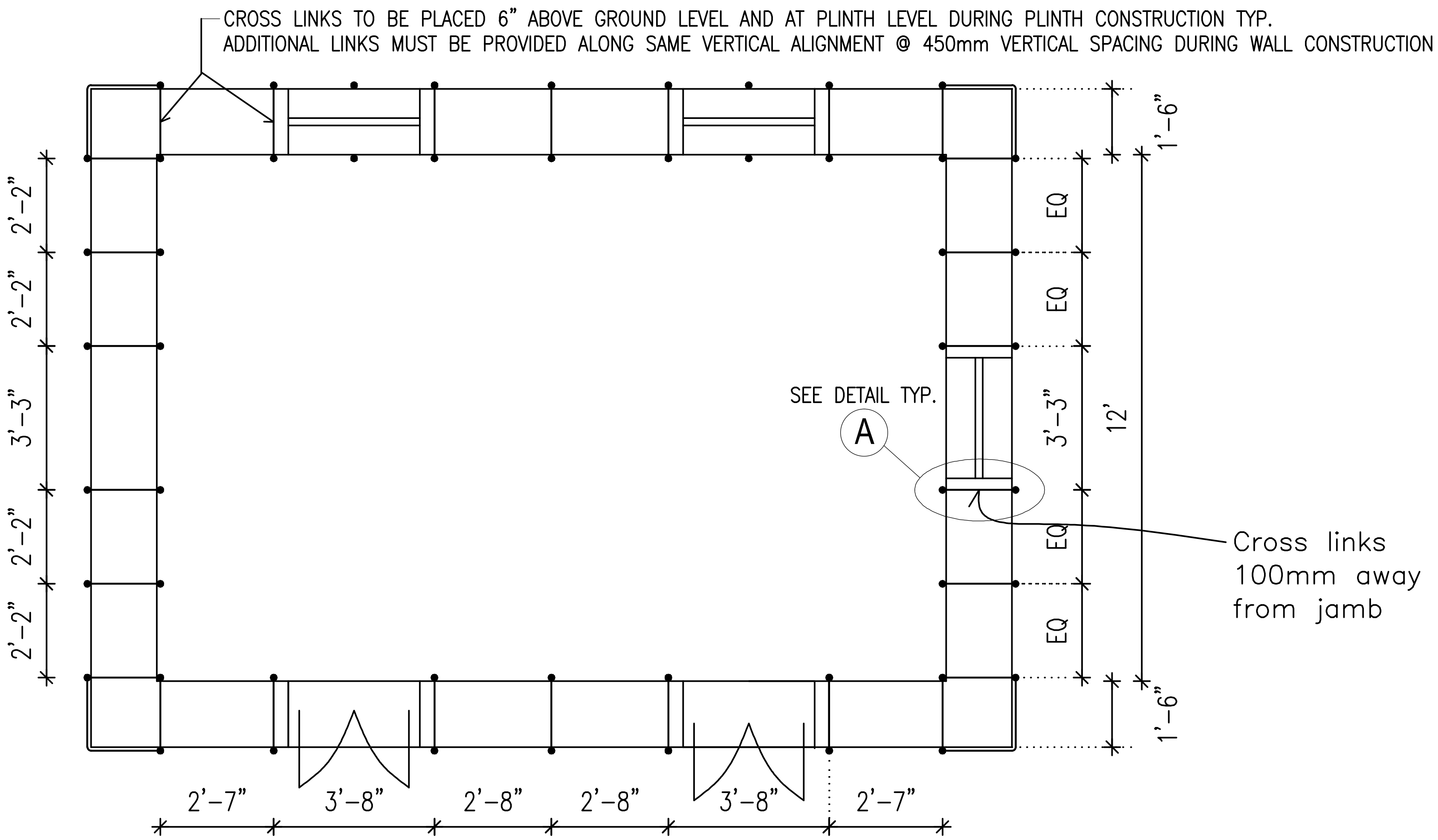
FOUNDATION PLAN



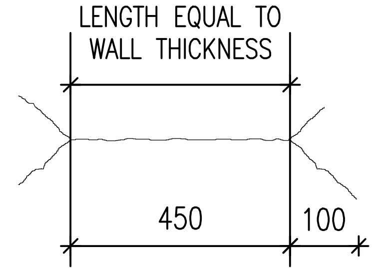
Total Plinth Area 29.3 Sq. m.
315 Sq. ft.

Note : All Dimension are in inch, unless noted otherwise.

Foundation Plan	Dt. : 08-03-2016
Design and Technology : NCPDP, India under guidance of Prof K S Jagadosh,	
Project support and Mandate : UNDP, Nepal	Local Partner and Project Management : CORD, Nepal
1storey house with containment reinforcement	dwn by : Arpit
National Center for Peoples'-Action in Diasaster Preparedness (NCPDP-CEDAP)	ckd by : Rupal
103, " Antariksh ", Panjarapole Cross Roads, Dr. Vikram Sarabhai Marg, Ahmedabad, Guj. 380015, INDIA.	Sheet = 1/12



DETAIL (A)
GI WIRE CROSS LINK



Two 14 ga (2mm dia) twisted GI wires with loose ends extending out 100mm on both side wall

LOCATION OF CROSS LINKS TO BE PLACED IN ALL STOREYS

See Notes 1,2,3 Sheet 6 for cross links

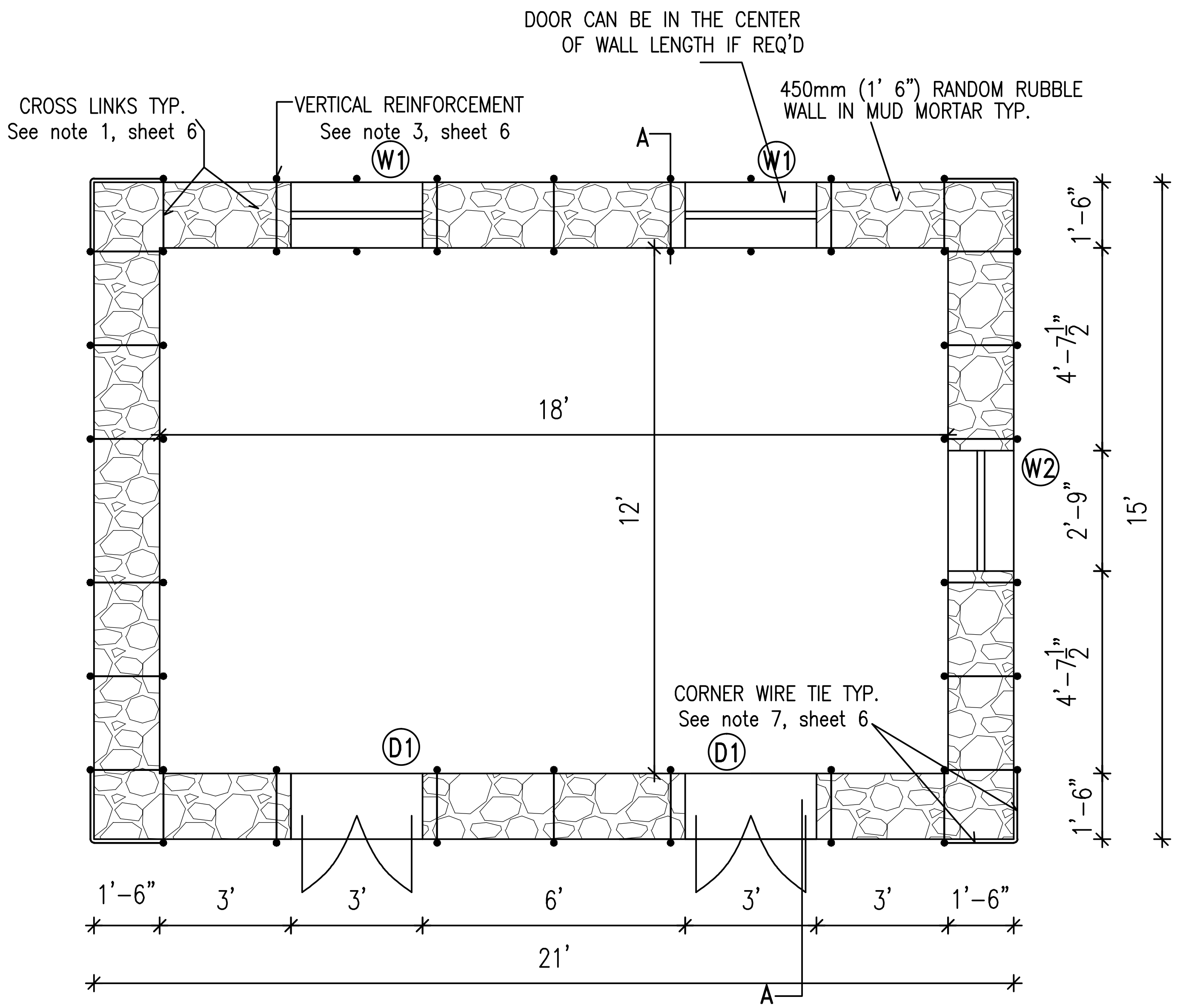
N

Plan North

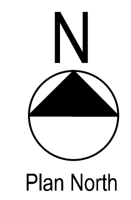
Total Plinth Area 29.3 Sq. m.
315 Sq. ft.

Note : All Dimension are in inch unless noted otherwise.

Cross-Link Location Plan	Dt. : 08-03-2016
Design and Technology : NCPDP, India under guidance of Prof K S Jagadosh,	
Project support and Mandate : UNDP, Nepal	Local Partner and Project Management : CORD, Nepal
1storey house with containment reinforcement	dwn by : Arpit
National Center for Peoples'-Action in Diasaster Preparedness (NCPDP-CEDAP)	ckd by : Rupal
103, " Antariksh ", Panjarapole Cross Roads, Dr. Vikram Sarabhai Marg, Ahmedabad, Guj. 380015, INDIA.	Sheet = 2/12



GROUND FLOOR PLAN



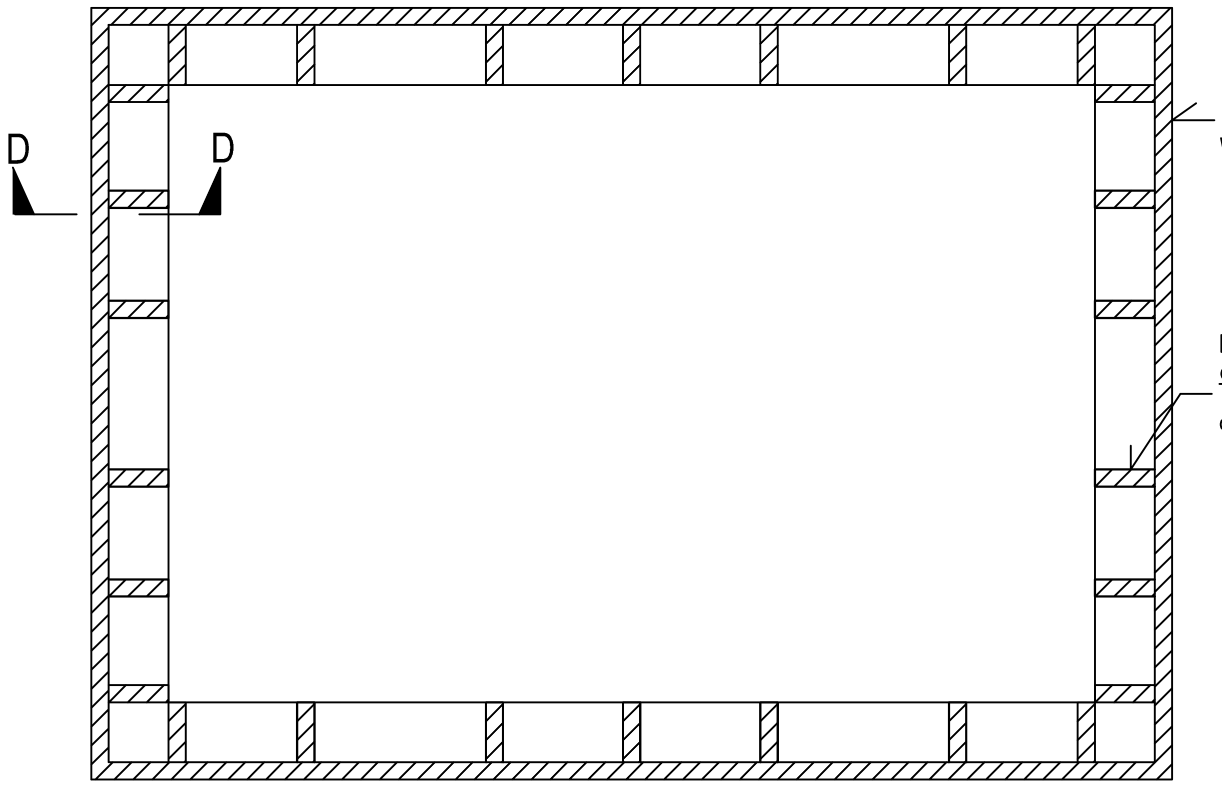
Total Plinth Area
29.3 Sq. m.
315 Sq. ft.

DOOR WINDOW OPENING SCHEDULE

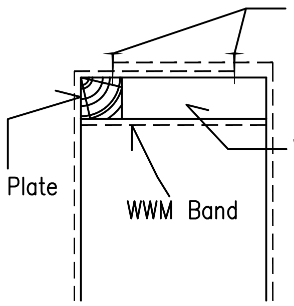
	WIDTH	HEIGHT	SILL	LINTEL
D1	900	1800	–	1800
D2	750	1800	–	1800
W1	900	900	900	1800
W2	825	900	900	1800
V	300	300	–	–

Note : All Dimension are in inch, unless noted otherwise.

Plan	Dt. : 08-03-2016
Design and Technology : NCPDP, India under guidance of Prof K S Jagadosh,	
Project support and Mandate : UNDP, Nepal	Local Partner and Project Management : CORD, Nepal
1storey house with containment reinforcement	dwn by : Arpit
National Center for Peoples'-Action in Diasaster Preparedness (NCPDP-CEDAP)	ckd by : Rupal
103, " Antariksh ", Panjarapole Cross Roads, Dr. Vikram Sarabhai Marg, Ahmedabad, Guj. 380015, INDIA.	Sheet = 3/12



TOP WALL PLATE PLAN



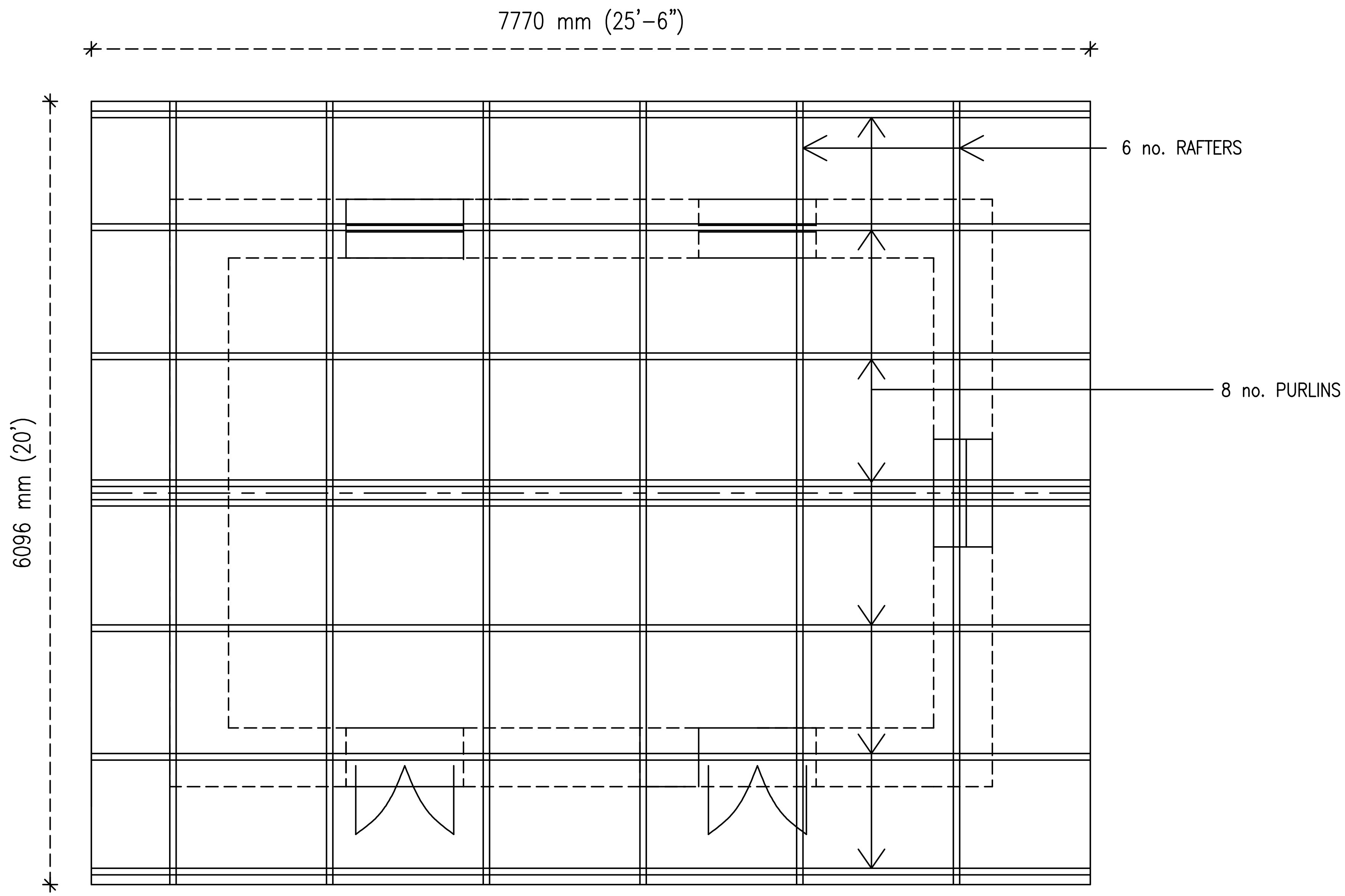
SECTION : D-D

N
Plan North

Total Plinth Area 29.3 Sq. m.
315 Sq. ft.

See Note 10 – Sheet 6 for timber to timber Connections

Top Wall Plate Plan	Dt. : 08-03-2016
Design and Technology : NCPDP, India under guidance of Prof K S Jagadosh,	
Project support and Mandate : UNDP, Nepal	Local Partner and Project Management : CORD, Nepal
1storey house with containment reinforcement	dwn by : Arpit
National Center for Peoples'–Action in Diasaster Preparedness (NCPDP-CEDAP)	ckd by : Rupal
103, " Antariksh ", Panjarapole Cross Roads, Dr. Vikram Sarabhai Marg, Ahmedabad, Guj. 380015, INDIA.	Sheet = 4/12



ROOF FRAME PLAN

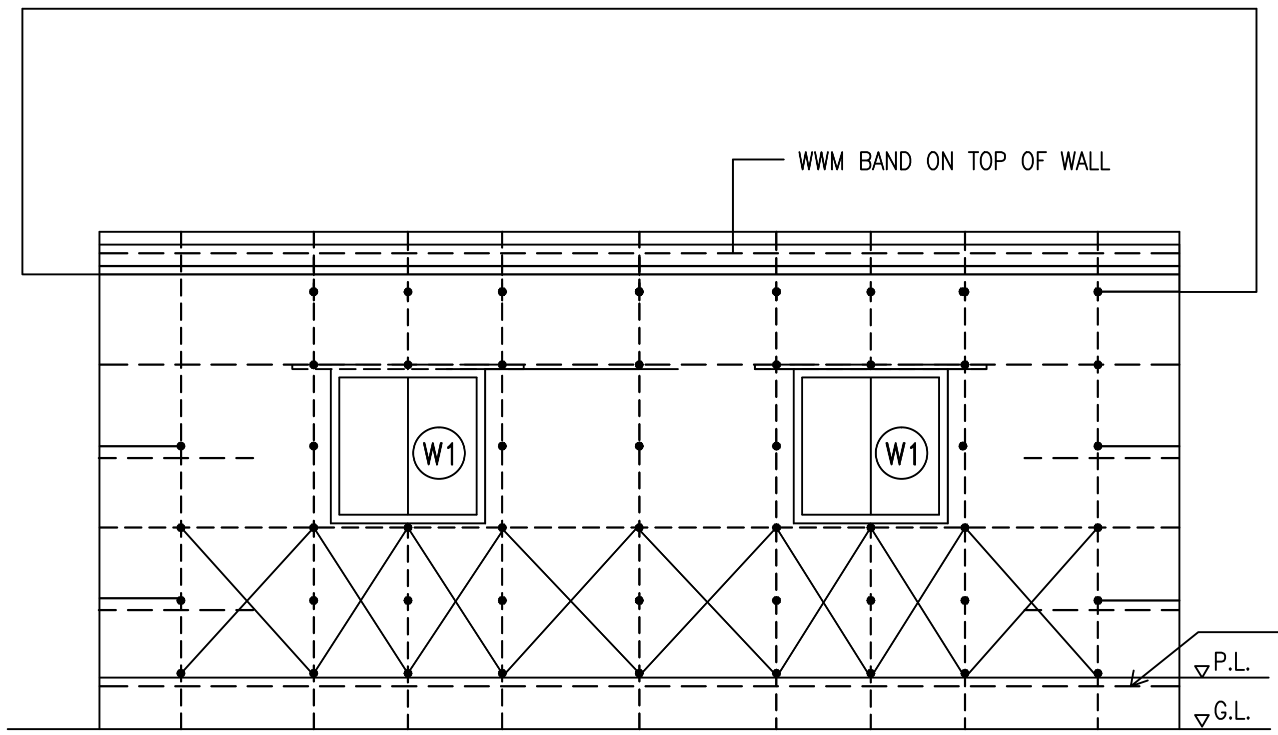
Roof Frame Plan		Dt. : 08-03-2016
Design and Technology : NCPDP, India under guidance of Prof K S Jagadosh,		
Project support and Mandate : UNDP, Nepal	Local Partner and Project Management : CORD, Nepal	
1storey house with containment reinforcement		dwn by : Arpit
National Center for Peoples'-Action in Diasaster Preparedness (NCPDP-CEDAP)		ckd by : Rupal
103, " Antariksh ", Panjarapole Cross Roads, Dr. Vikram Sarabhai Marg, Ahmedabad, Guj. 380015, INDIA.		Sheet = 5/12

TECHNICAL NOTES

* Note 1: Cross–links to be of 2–14 ga. (2mm) galvanized wires placed @ 450mm (18") vertical spacing. All cross links below ground to be of Aluminum. See details on Sheet–8.
* Note 2: When wall length is twice the height or more then it is Long wall. Otherwise it is Short wall.
* Note 3: The maximum spacing for vertical reinforcement of 4mm galvanized wire, or 6mm Aluminum wire on inside and outside faces in long wall is 900mm (3'–0") and in Short wall is 1,200mm (4' 0"). All wires below ground to be of Aluminum.
* Note 4: All vertical reinforcement to be anchored to cross–links in plinth and foundation as shown in Foundation Detail on Sheet–8.
* Note 5: All Seismic Band are to be made of Galvanized 14 gauge (2mm) Weld Wire Mesh having wire spacing of 31x31mm in both directions plus 2 – 4mm GI wires. Bands at Plinth, Sill, Lintle, Floor and Eave levels are to be 350mm wide.It is to be placed in mud mortar.If not galvanized protect WWM with a coat of Red–oxide. See Detail Sheet 8.
* Note 6: Diagonal ties to be 1–14 ga. (2mm) galvanized wire tied between cross links on inside and outside faces.
* Note 7: Corner ties to be 1–14 ga. (2mm) galvanized wire tied around wall face between cross–link at corner.

* Note 9: Foundation as per Det.Y on Sheet–8 is the recommended option, only if 4mm aluminum wire is available or else Det,X is to be used. In case of existing foundation use Det.X
* Note 10: All timber to timber connections should be strengthened using 14ga GI wires or metal straps.

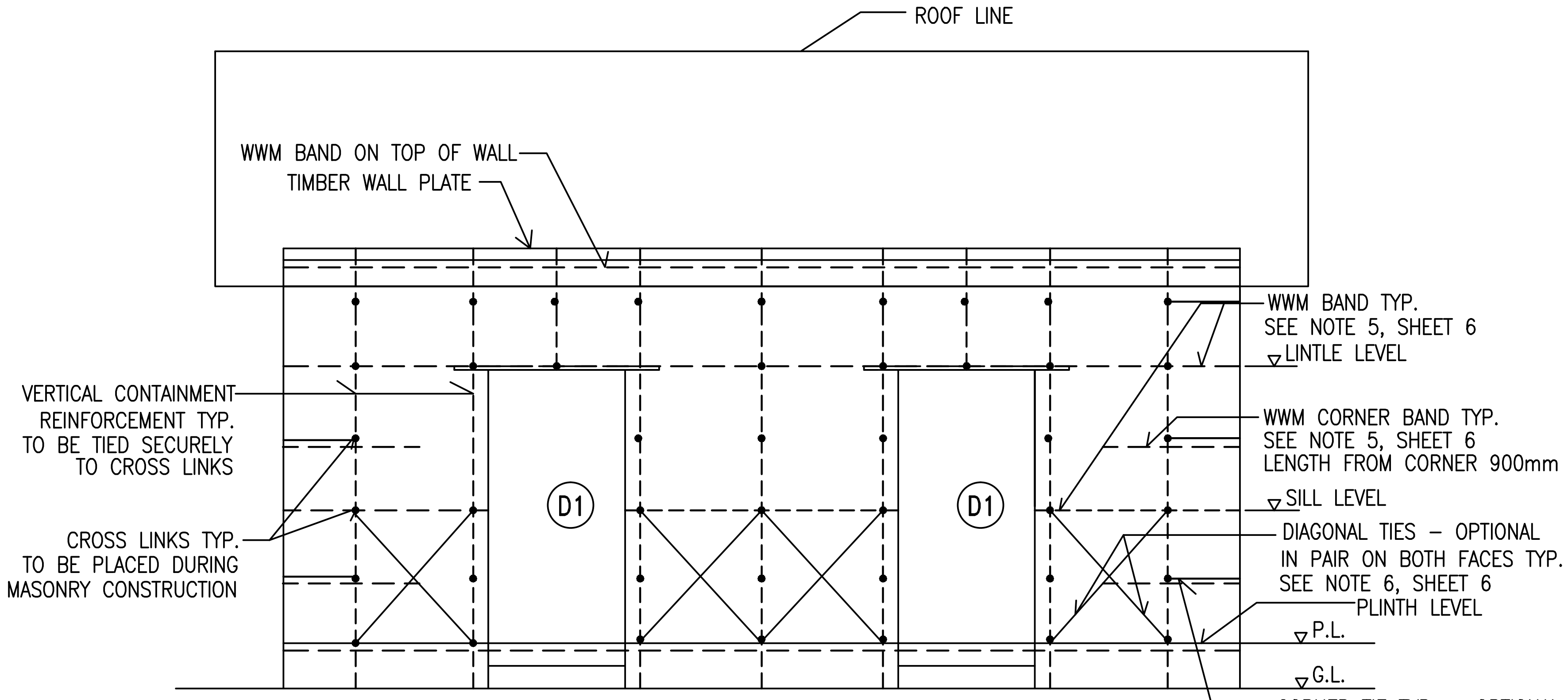
Technical Notes		Dt. : 08–03–2016
Design and Technology : NCPDP, India under guidance of Prof K S Jagadosh,		
Project support and Mandate : UNDP, Nepal	Local Partner and Project Management : CORD, Nepal	
1storey house with containment reinforcement		dwn by : Arpit
National Center for Peoples'–Action in Diasaster Preparedness (NCPDP–CEDAP)		ckd by : Rupal
103, " Antariksh ", Panjarapole Cross Roads, Dr. Vikram Sarabhai Marg, Ahmedabad, Guj. 380015, INDIA.		Sheet = 6/12



NORTH SIDE ELEVATION

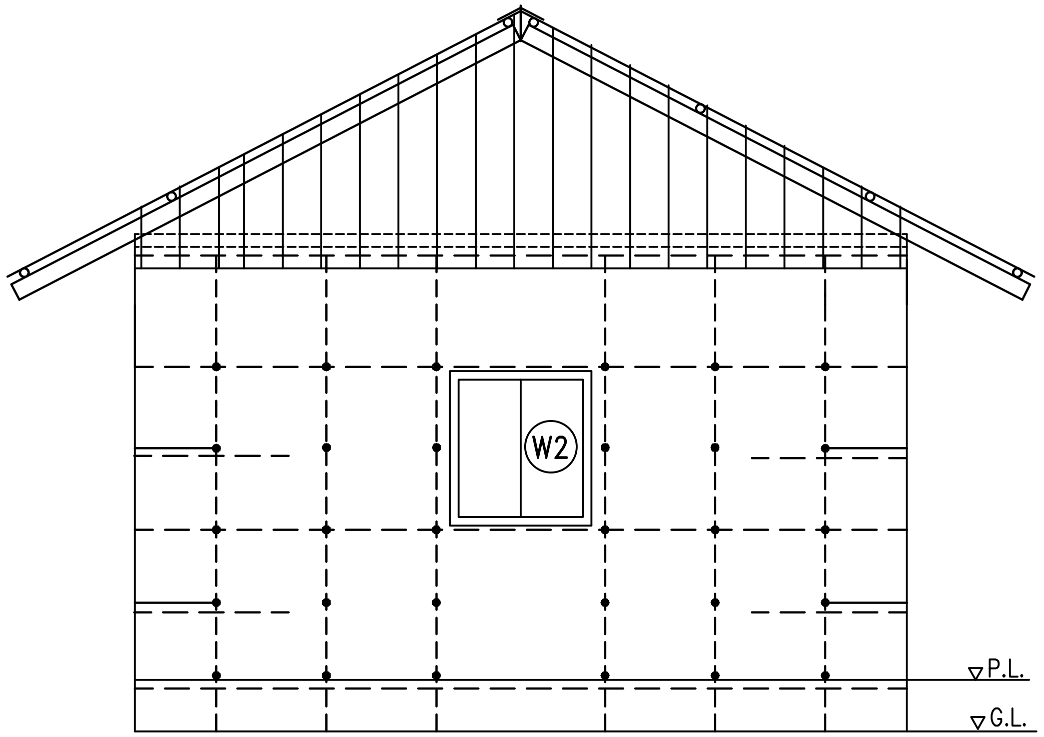
NOTE :
ALL BANDS AND WALL PLATES
TO BE CONTINUOUS OVER ALL WALLS

Rear Elevations	Dt. : 08-03-2016
Design and Technology : NCPDP, India under guidance of Prof K S Jagadosh,	
Project support and Mandate : UNDP, Nepal	Local Partner and Project Management : CORD, Nepal
1storey house with containment reinforcement	dwn by : Arpit
National Center for Peoples'-Action in Diasaster Preparedness (NCPDP-CEDAP)	ckd by : Rupal
103, " Antariksh ", Panjarapole Cross Roads, Dr. Vikram Sarabhai Marg, Ahmedabad, Guj. 380015, INDIA.	Sheet = 7/12

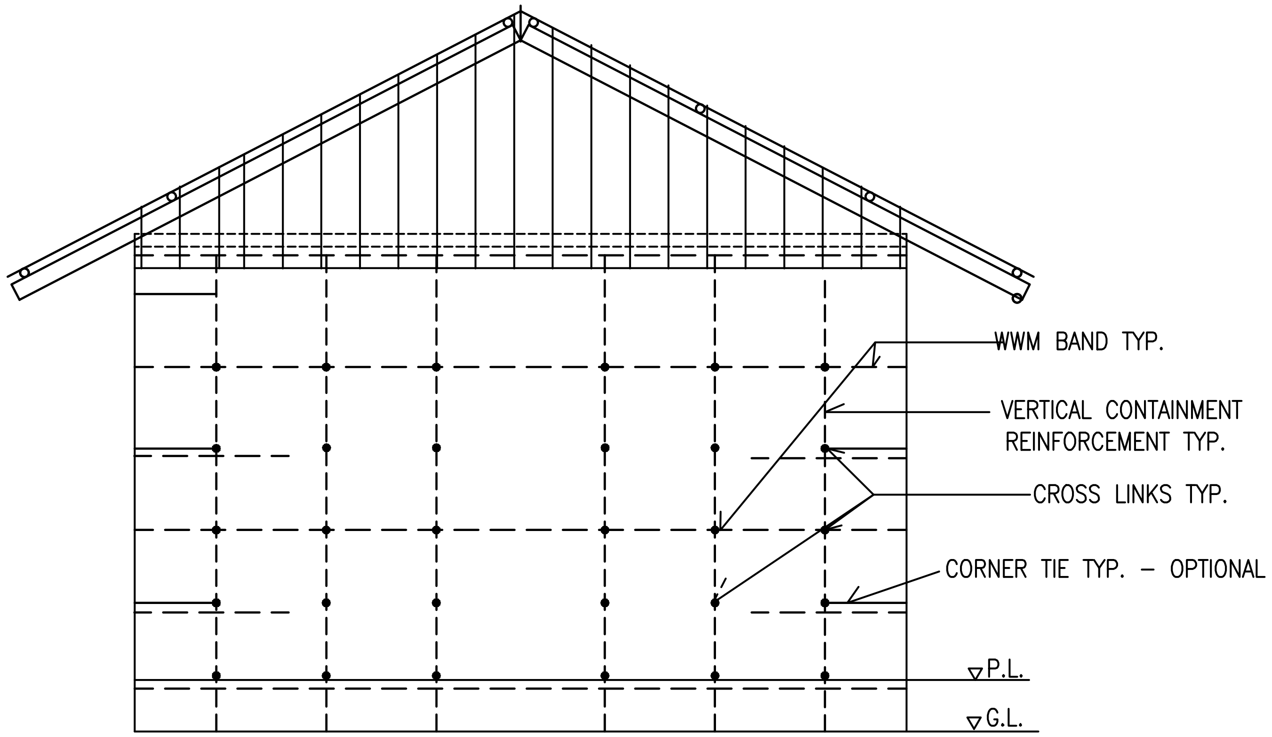


SOUTH SIDE ELEVATION

Front Elevations	Dt. : 08-03-2016
Design and Technology : NCPDP, India under guidance of Prof K S Jagadosh,	
Project support and Mandate : UNDP, Nepal	Local Partner and Project Management : CORD, Nepal
1storey house with containment reinforcement	dwn by : Arpit
National Center for Peoples'-Action in Diasaster Preparedness (NCPDP-CEDAP)	ckd by : Rupal
103, " Antariksh ", Panjarapole Cross Roads, Dr. Vikram Sarabhai Marg, Ahmedabad, Guj. 380015, INDIA.	Sheet = 8/12

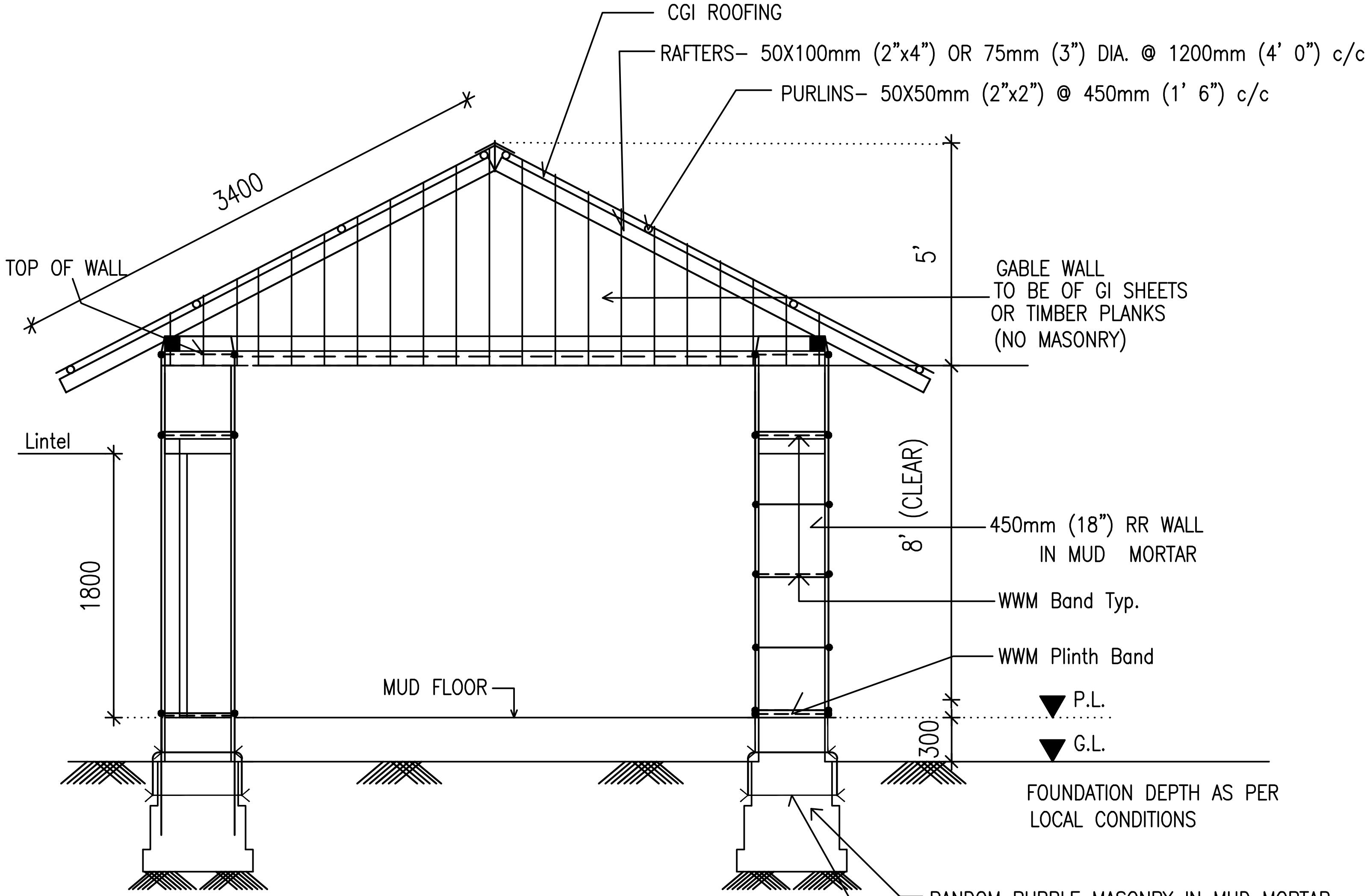


EAST SIDE ELEVATION



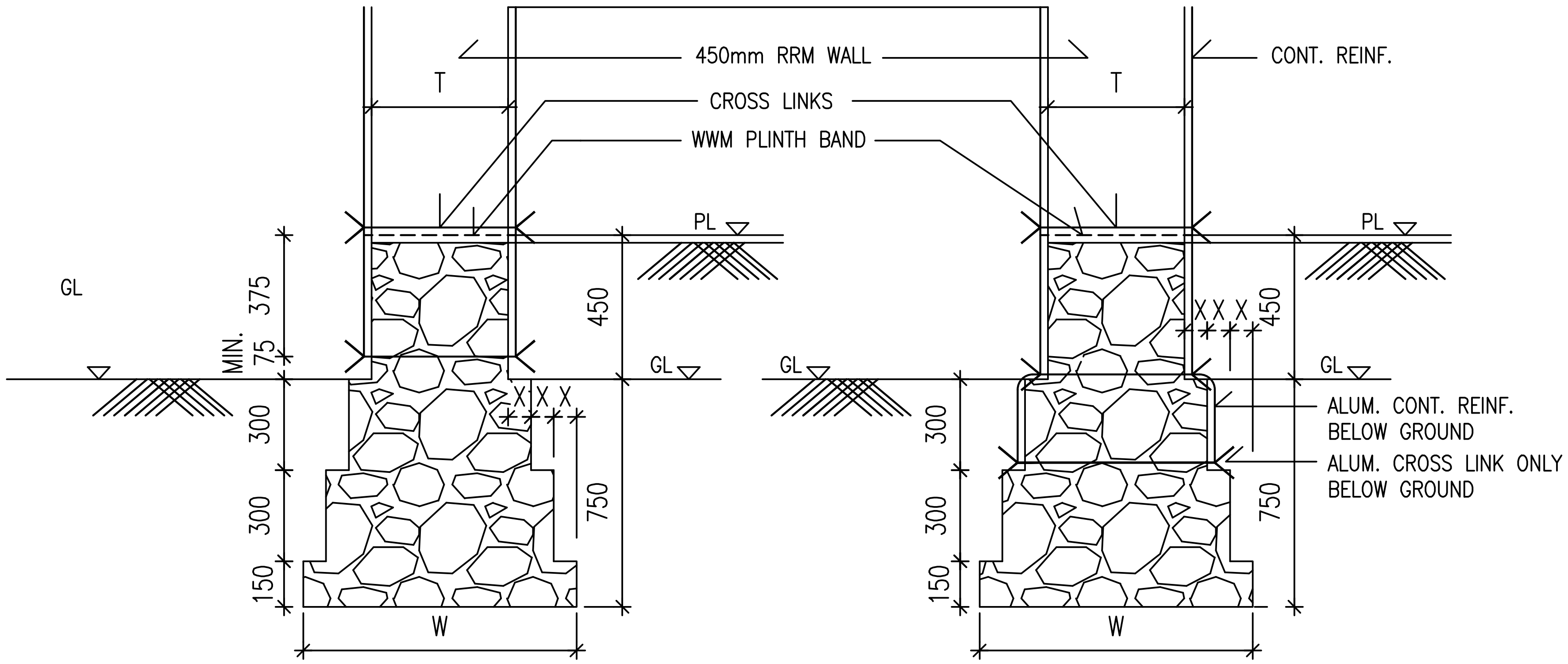
WEST SIDE ELEVATION

Side Elevations	Dt. : 08-03-2016
Design and Technology : NCPDP, India under guidance of Prof K S Jagadosh,	
Project support and Mandate : UNDP, Nepal	Local Partner and Project Management : CORD, Nepal
1storey house with containment reinforcement	dwn by : Arpit
National Center for Peoples'–Action in Diasaster Preparedness (NCPDP–CEDAP)	ckd by : Rupal
103, " Antariksh ", Panjarapole Cross Roads, Dr. Vikram Sarabhai Marg, Ahmedabad, Guj. 380015, INDIA.	Sheet = 9/12



SECTION : A-A

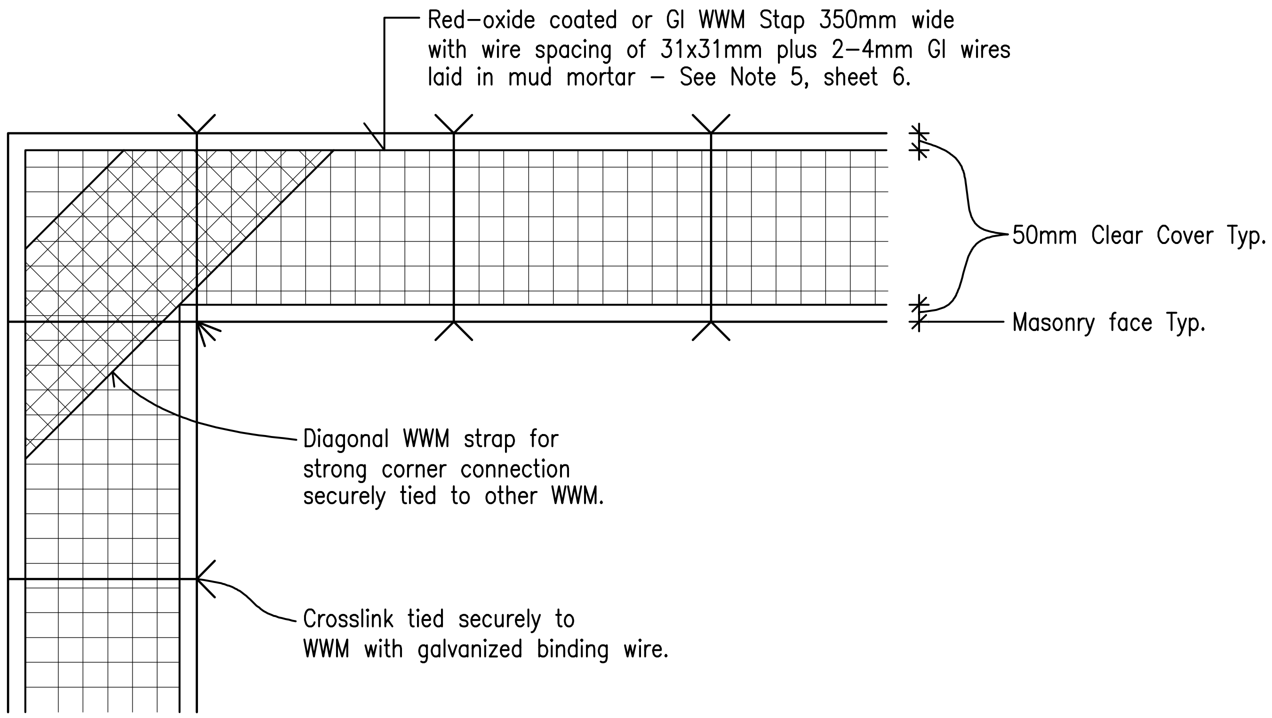
Details	Dt. : 08–03–2016
Design and Technology : NCPDP, India under guidance of Prof K S Jagadosh,	
Project support and Mandate : UNDP, Nepal	Local Partner and Project Management : CORD, Nepal
1storey house with containment reinforcement	dwn by : Arpit
National Center for Peoples'–Action in Diasaster Preparedness (NCPDP–CEDAP)	ckd by : Rupal
103, " Antariksh ", Panjarapole Cross Roads, Dr. Vikram Sarabhai Marg, Ahmedabad, Guj. 380015, INDIA.	Sheet = 10/12



DETAIL - X
ECONOMIC OPTION
Also to be used with
existing foundation

DETAIL - Y
RECOMMENDED OPTION
Only if aluminum wire are available

Details	Dt. : 08-03-2016
Design and Technology : NCPDP, India under guidance of Prof K S Jagadosh,	
Project support and Mandate : UNDP, Nepal	Local Partner and Project Management : CORD, Nepal
1storey house with containment reinforcement	dwn by : Arpit
National Center for Peoples'-Action in Diasaster Preparedness (NCPDP-CEDAP)	ckd by : Rupal
103, " Antariksh ", Panjarapole Cross Roads, Dr. Vikram Sarabhai Marg, Ahmedabad, Guj. 380015, INDIA.	Sheet = 11/12



WELD WIRE MESH BAND DETAIL

Details	Dt. : 08-03-2016
Design and Technology : NCPDP, India under guidance of Prof K S Jagadosh,	
Project support and Mandate : UNDP, Nepal	Local Partner and Project Management : CORD, Nepal
1storey house with containment reinforcement	dwn by : Arpit
National Center for Peoples'-Action in Diasaster Preparedness (NCPDP-CEDAP)	ckd by : Rupal
103, " Antariksh ", Panjarapole Cross Roads, Dr. Vikram Sarabhai Marg, Ahmedabad, Guj. 380015, INDIA.	Sheet = 12/12

Bill of Quantities

Shelter Type: **School Design**

Stone Masonry (Mud Mortar) with containment reinforcement

Item No.	Description of Works	Unit	Quantity	Rate	Amount (NRS)	Remarks
1	Earthwork in excavation in foundations in gravel mix soil including dressing of sides, ramming of bottom and lead upto 10m, all complete as per drawing, specification and instructions.	Cu. M	11.96	628.26	7,513.99	
2	Stone masonry work with mud mortar in foundation in level, shape including transportation and supplying of materials, all complete as per drawing, specifications and instructions.	Cu. M	10.05	4,905.90	49,304.30	
3	Stone masonry work in between foundation and plinth level including transportation and supplying of materials, all complete as per drawing, specifications and instructions.	Cu. M	4.31	4,905.90	21,144.43	
4	Soil filling in between foundation and plinth level including leveling, ramming of surface, transportation and supplying of materials, all complete as per drawing, specifications and instructions.	Cu. M	7.53	900.45	6,780.39	
5	Local high strength wood work in any level, size and shape for Door, Window Shutter,Wall plate,Stub for tying containment,Rafter & Purlins as required all complete as per drawing, specification and instructions.	Cu. M	1.20	84,381.46	101,257.75	
6	Local high strength wood work in any level, size and shape for door, window frame as required all complete as per drawing, specification and instructions.	Cu. M	0.15	108,369.86	16,255.48	
7	Installation and positioning of C.G.I sheet work in roof in level all complete as per drawing, specification and instructions excluding transportation charge.	Sq. M.	59.36	989.43	58,732.56	
8	Providing and laying stone masonry wall in mud mortar with both side fair finish including cost of scaffolding, filling and raking out joints wherever required as per drawings, specifications and instructions.	Cu.M.	21.51	4,905.90	105,525.91	
9	Installation and positioning of GI wire (4mm ɸ) at wall all complete as per drawing, specification and instructions excluding transportation charge.	Kg	32.99	200.00	6,598.00	
10	Installation and positioning of GI wire (2mm ɸ) for cross links at wall all complete as per drawing, specification and instructions excluding transportation charge.	Kg	55.51	149.90	8,320.95	
11	Holdfast	Nos	24.00	30.00	720.00	
12	Hinge	Nos	18.00	45.00	810.00	
13	Handle	Nos	10.00	25.00	250.00	
14	Cheskini	Nos	10.00	45.00	450.00	
15	Lock	Nos	2.00	200.00	400.00	
				Total (A)	**384,063.76**	

CALCULATION OF QUANTITIES

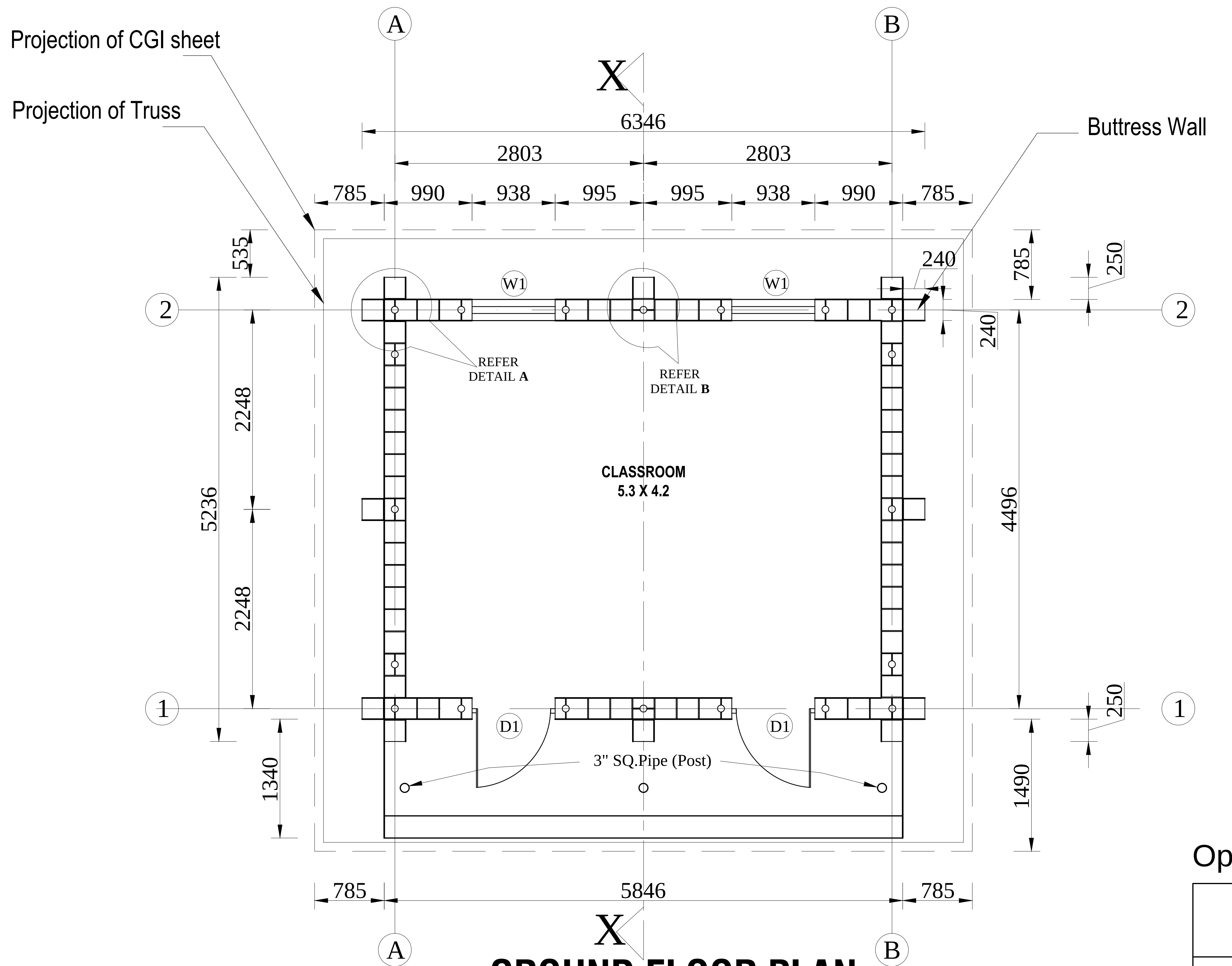
Shelter Type: **School Design**

Stone Masonry (Mud Mortar) with containment reinforcement

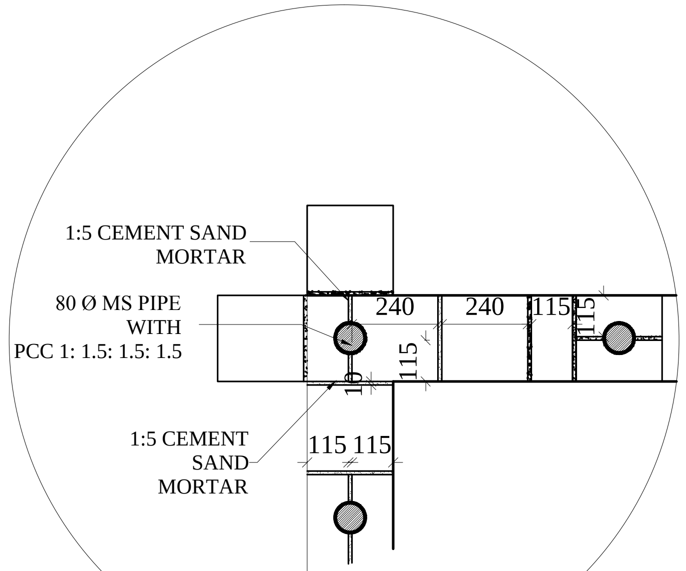
Item No.	Details of items	No.	Dimensions (m) L	B	H/D	Quantities	Total Quantities	Unit	Remarks
A	**Foundation Work**								
1	**Earthwork in excavation in foundations in gravel mix soil including dressing of sides, ramming of bottom and lead upto 10m, all complete as per drawing, specification and instructions.**						**11.96**	**Cu. M**	
	Long wall	2	6.68	0.75	0.750	7.52			
	Short wall	2	3.95	0.75	0.750	4.45			
					Total	**11.964**			
2	**Stone masonry work with mud mortar in foundation in level, shape including transportation and supplying of materials, all complete as per drawing, specifications and instructions.**						**10.05**	**Cu. M**	
	Long wall	2	6.68	0.47		6.31			
	Short wall	2	3.95	0.47		3.74			
					Total	**10.050**			
B	**Superstructure Work**								
3	**Stone masonry work in between foundation and plinth level including transportation and supplying of materials, all complete as per drawing, specifications and instructions.**						**4.31**	**Cu. M**	
	Long wall	2	6.68	0.45	0.450	2.71			
	Short wall	2	3.95	0.45	0.450	1.60			
					Total	**4.307**			
4	**Soil filling in between foundation and plinth level including leveling, ramming of surface, transportation and supplying of materials, all complete as per drawing, specifications and instructions.**						**7.53**	**Cu. M**	
		1	3.66	5.49	0.38	7.53			
					Total	**7.525**			
5	**Local high strength wood work in any level, size and shape for Door, Window Shutter,Wall plate,Stub for tying containment,Rafter & Purlins as required all complete as per drawing, specification and instructions.**						**1.20**	**Cu. M**	
	Door D1	2	0.90	0.037	1.80	0.12			
	Window W1	2	0.90	0.037	0.90	0.06			
	Window W2	1	0.90	0.037	0.90	0.03			
	Wall Plate(long wall)	2	6.39	0.1	0.1	0.13			
	Wall Plate(short wall)	2	4.56	0.1	0.1	0.09			
	Timber stub for tying containment	30	0.45	0.1	0.1	0.14			
	Rafter	12	3.4	0.05	0.1	0.20			
	Purlin	8	7.77	0.05	0.05	0.16			
	Timber lintel on all opening	5	1.66	0.45	0.075	0.28			
					Total	**1.20**			
6	**Local high strength wood work in any level, size and shape for door, window frame as required all complete as per drawing, specification and instructions.**						**0.15**	**Cu. M**	
	Door D1	2	4.5	0.1	0.075	0.07			
	Window W1	2	3.6	0.1	0.075	0.05			
	Window W2	1	3.45	0.1	0.075	0.03			
					Total	**0.15**			
7	**Installation and positioning of C.G.I sheet work in roof in level all complete as per drawing, specification and instructions excluding transportation charge.**						**59.36**	**Sq. M.**	
	Roofing	1	7.77	6.096		47.37			
	for ridge cover(18" wide)	1	7.77	0.45		3.50			
	For gable wall	2	4.251	area		8.50			
					Total	**59.36**			
8	**Providing and laying stone masonry wall in mud mortar with both side fair finish including cost of scaffolding, filling and raking out joints wherever required as per drawings, specifications and instructions.**						**21.51**	**Cu.M.**	
	Long wall	2	6.390	0.45	2.44	14.02			
	Short wall	2	4.560	0.45	2.44	10.01			
	Deduction of opening					-			
	D1	-2	0.900	0.45	1.80	(1.46)			
	W1	-2	0.900	0.45	0.90	(0.73)			
	W2	-1	0.825	0.45	0.90	(0.33)			
					Total	**21.51**			

Item No.	Details of items	No.	Dimensions (m)			Quantities	Total Quantities	Unit	Remarks
			L	B	H/D				
9	**Installation and positioning of GI wire (4mm ϕ) at wall all complete as per drawing, specification and instructions excluding transportation charge.**						**32.99**	**Kg**	
	For Vertical Reinforcement inside and outside of wall								
	GI Wire running vertically (outer)	24	3.84			93.48			
	GI Wire running vertically (inner)	20	3.675			74.73			
	For Seismic band(2-4mm)					-			
	Plinth	2	22			43.80			
	Sill	2	22			43.80			
	Lintel	2	22			43.80			
	at Top of wall	2	22			43.80			
	Deduction of opening	-1	8.85			(8.85)			
					Total	**32.99**			
10	**Installation and positioning of GI wire (2mm ϕ) for cross links at wall all complete as per drawing, specification and instructions excluding transportation charge.**						**55.51**	**Kg**	
	For cross links + diagonal ties								
	GI Wire running vertically (Long wall)	17	6.39			109.06			
	GI Wire running vertically (short wall)	17	4.56			77.82			
	GI Wire running Horizontally (Long wall)	28	3.84			109.06			
	GI Wire running Horizontally (short wall)	20	3.84			77.82			
						-			
	For Seismic band(31mmx31mm spacing)					-			
	at Plinth,Lintel,Sill and top of the wall	45	22			989.03			
		2826	0.35			989.03			
	Deduction of opening	-11	4.425			(49.96)			
		-143	0.35			(49.96)			
					Total	**55.51**			
	Accessories								
11	Holdfast	24				24.000	**24.000**	**Nos**	
12	Hinge	18				18.000	**18.000**	**Nos**	
13	Handle	10				10.000	**10.000**	**Nos**	
14	Cheskini	10				10.000	**10.000**	**Nos**	
15	Lock	2				2.000	**2.000**	**Nos**	

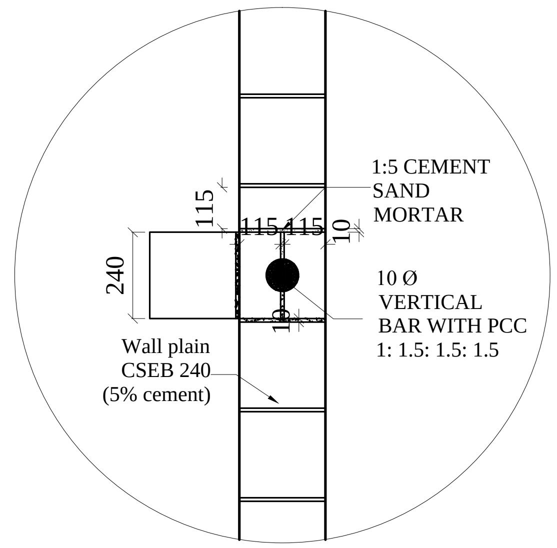
Annex 2B: Design and Drawings of CSEB Construction



GROUND FLOOR PLAN



DETAIL AT A



DETAIL AT B

Opening Schedule

Element	SIZE	No.
W1	938*1310	2
D1	938*2100	2

CENTER OF RESILIENT DEVELOPMENT Basundhara, Dhapasi G.P.O. Box: 1681, Kathmandu Email: info@cordvia.org CORD	PROJECT: PERMANENT SCHOOL DESIGN BLOCK MASONRY OF COMPRESED STABILIZED EARTHEN BLOCK(CSEB)	SHEET TITLE: PLAN AND DETAILS	DRAWN BY: Er.Samrak Karmacharya APPROVED BY: Er. Hari Darshan Shrestha	DATE: Feb, 2016 SCALE: 1:50	DWG.NR. A-01 REV. 00

REV	DESCRIPTION HISTORY	BY	DATE

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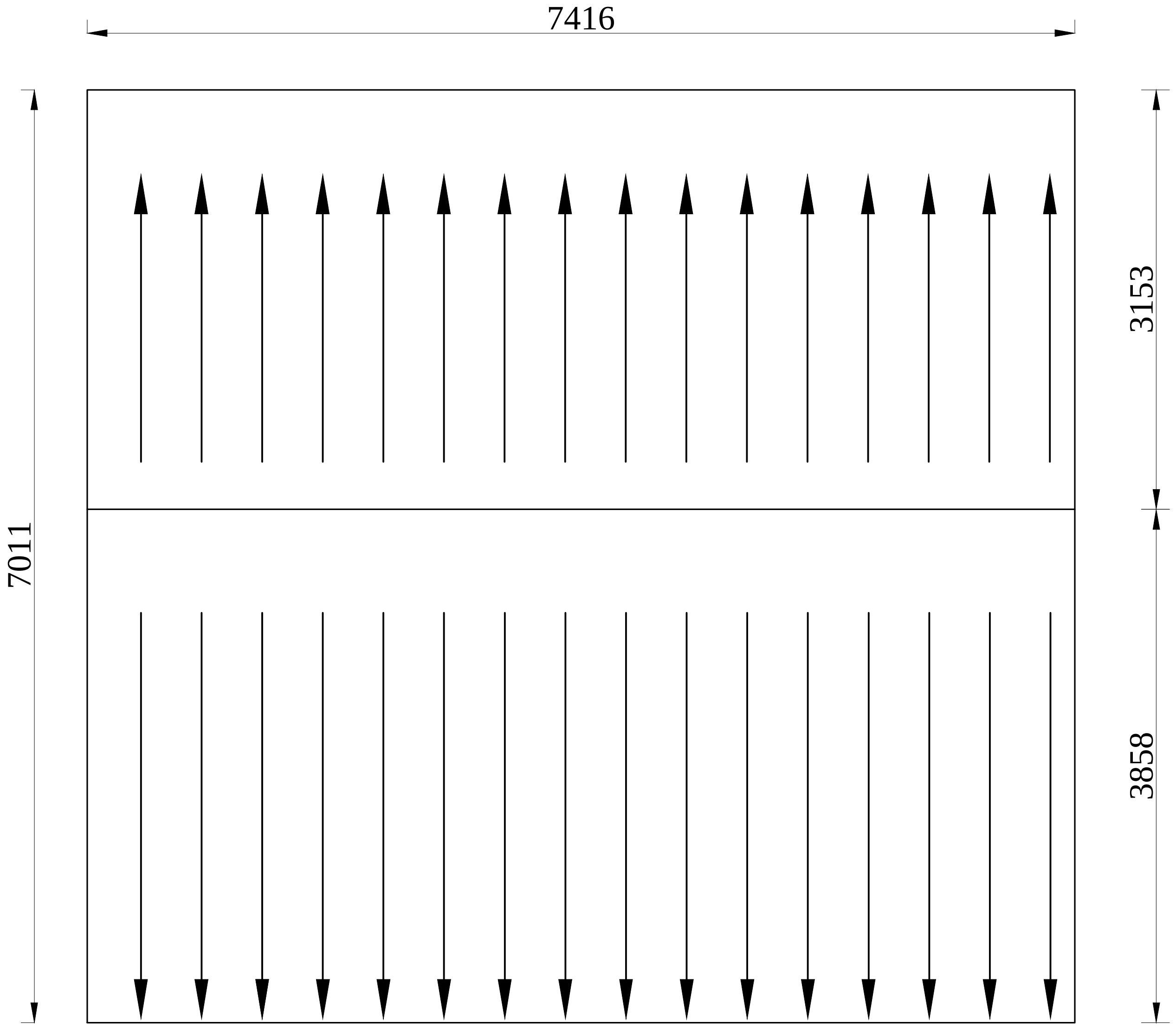
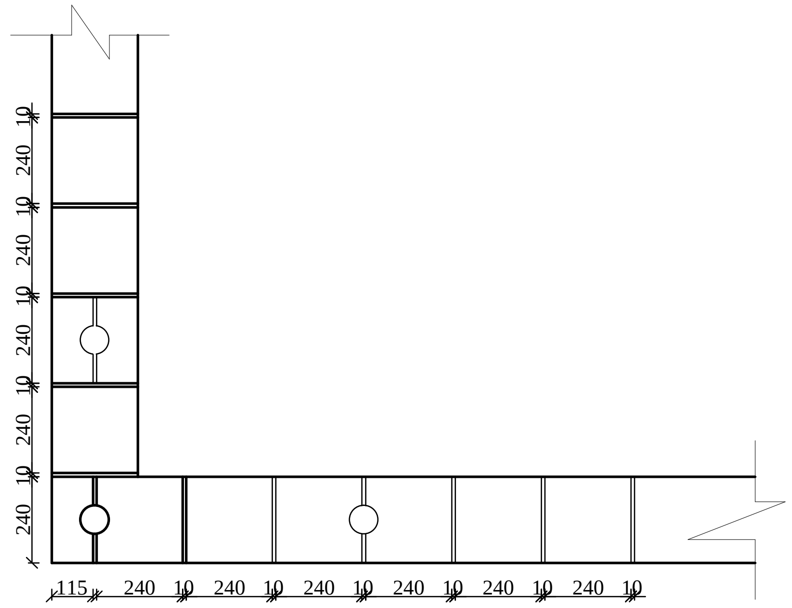
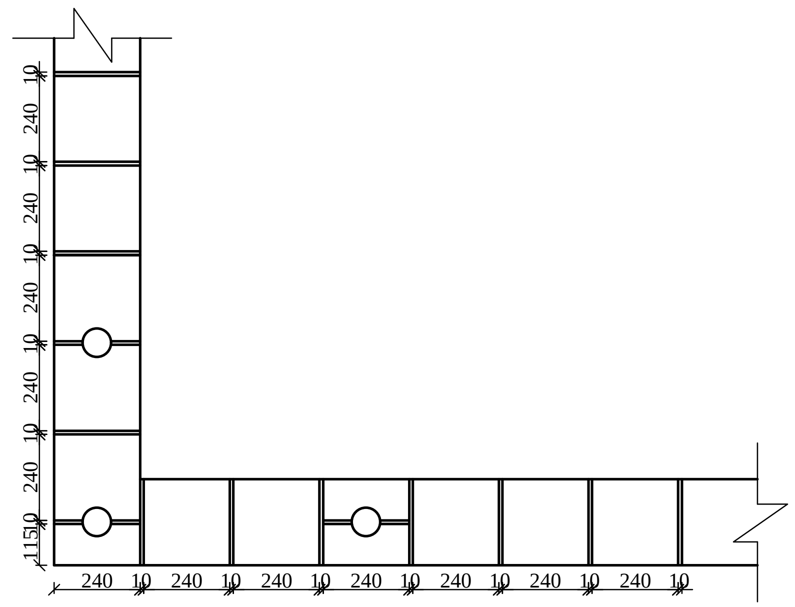


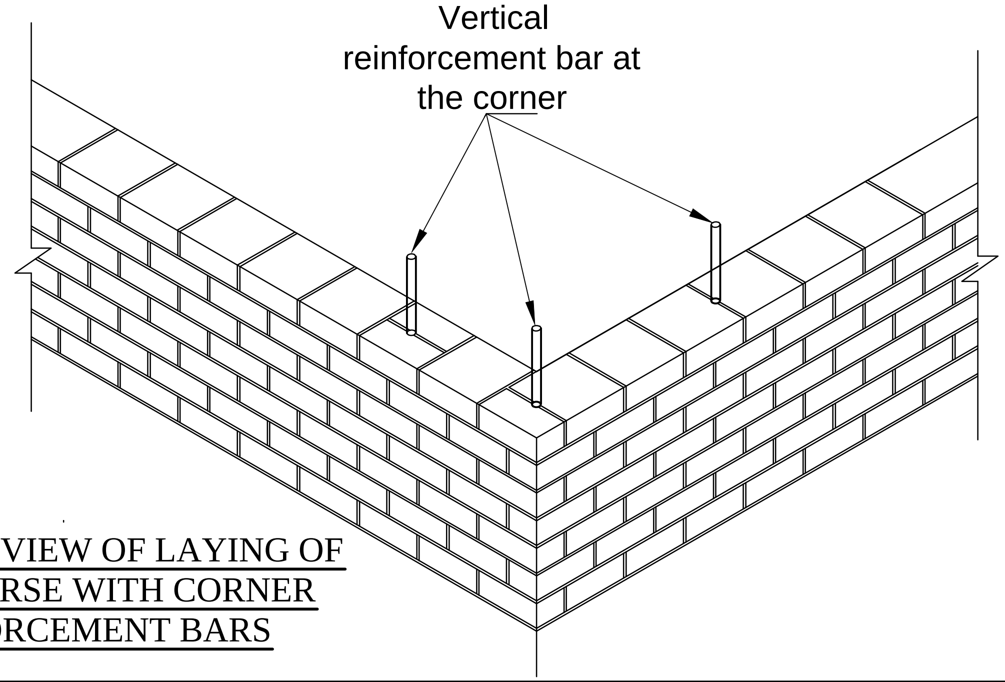
ROOF PLAN



Plan of laying of CSEB
(1st course)
SCALE 1:20



Plan of laying of CSEB
(2nd course)
SCALE 1:20



ISOMETRIC VIEW OF LAYING OF CSEB COURSE WITH CORNER REINFORCEMENT BARS

CENTER OF RESILIENT DEVELOPMENT
Basundhara, Dhapasi
G.P.O. Box: 1681, Kathmandu
Email: info@cordvia.org
CORD

PROJECT:
PERMANENT SCHOOL DESIGN
BLOCK MASONRY OF COMPRESED STABILIZED EARTHEN BLOCK(CSEB)

SHEET TITLE:
ROOF PLAN AND CSEB WORK DETAIL

DRAWN BY:
Er.Samrak Karmacharya

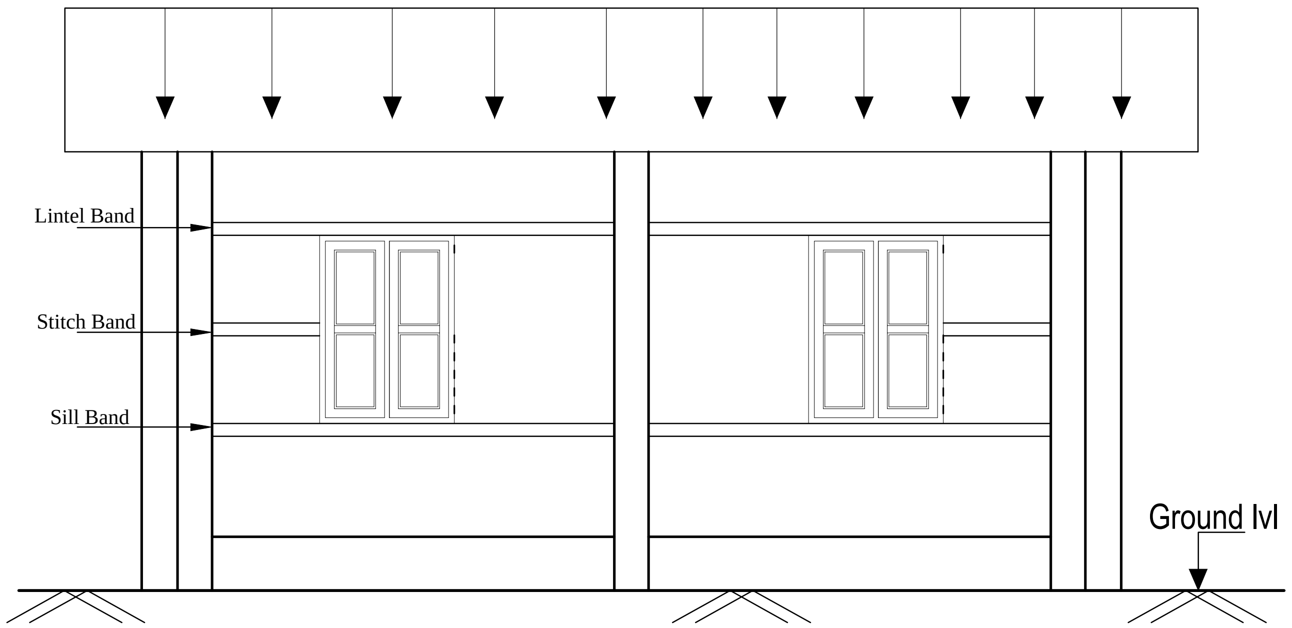
APPROVED BY: Er. Hari Darshan Shrestha

DATE:
Feb, 2016

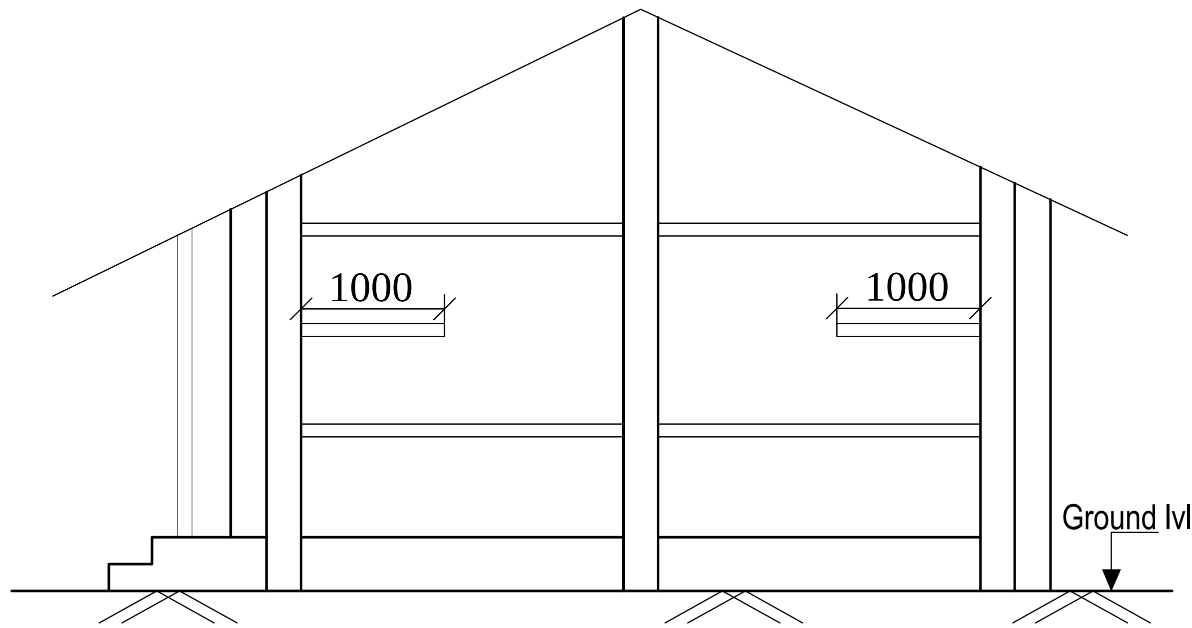
SCALE: 1:50

DWG.NR.	REV	DESCRIPTION HISTORY	BY	DATE
A-02				
REV. 00				

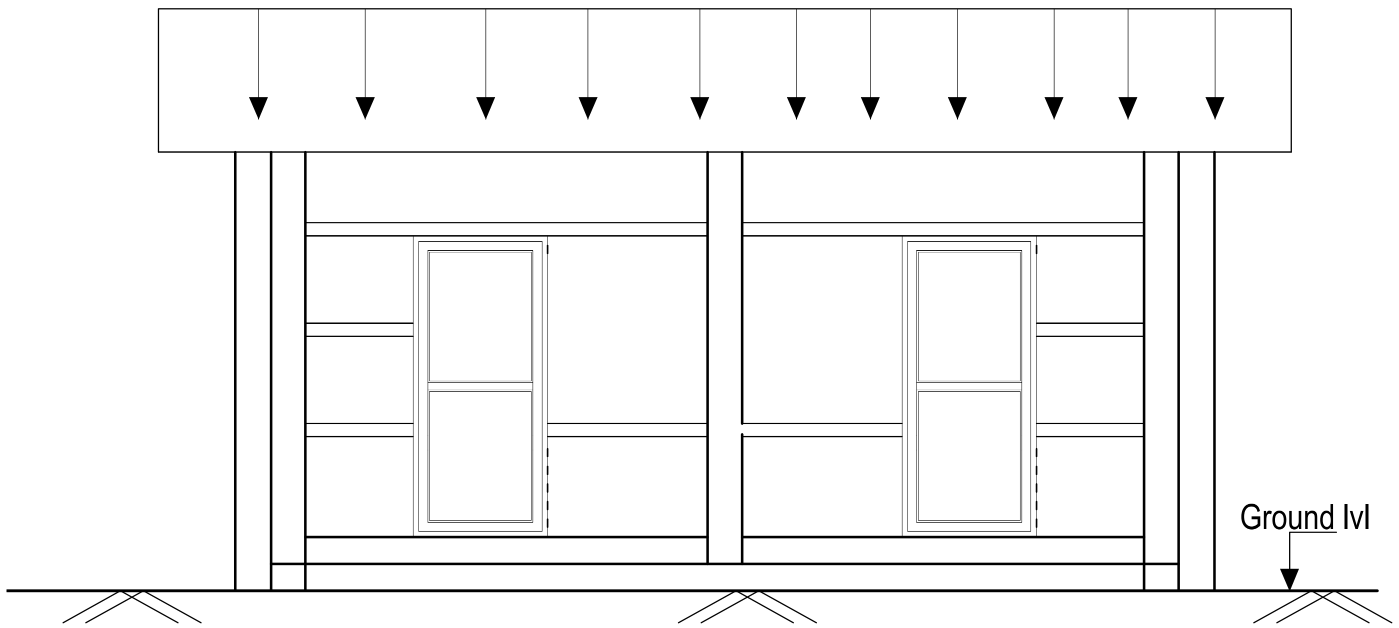
N



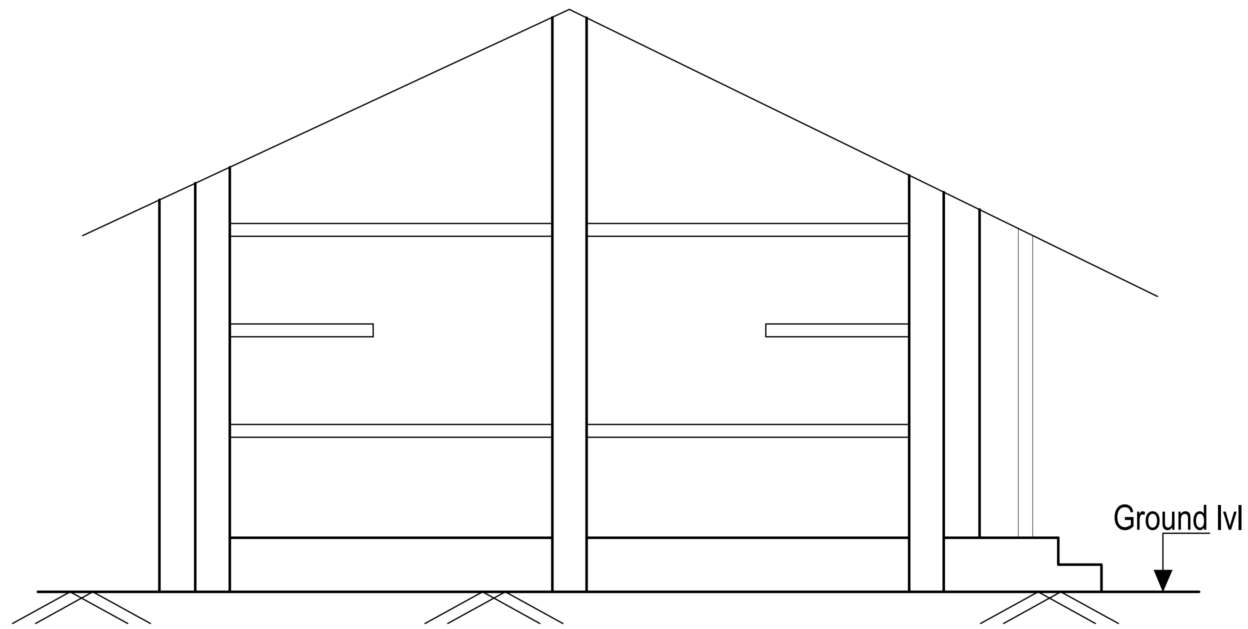
Rear Elevation



Right Side Elevation



Front Elevation



Left Side Elevation

CENTER OF RESILIENT DEVELOPMENT
Basundhara, Dhapasi
G.P.O. Box: 1681, Kathmandu
Email: info@cordvia.org

PROJECT:
PERMANENT SCHOOL DESIGN
BLOCK MASONRY OF COMPRESED STABILIZED EARTHEN BLOCK(CSEB)

SHEET TITLE:
ELEVATIONS

DRAWN BY:
Er.Samrak Karmacharya

APPROVED BY: Er. Hari Darshan Shrestha

DATE:
Feb, 2016

SCALE: 1:50

DWG.NR.	REV	DESCRIPTION HISTORY	BY	DATE
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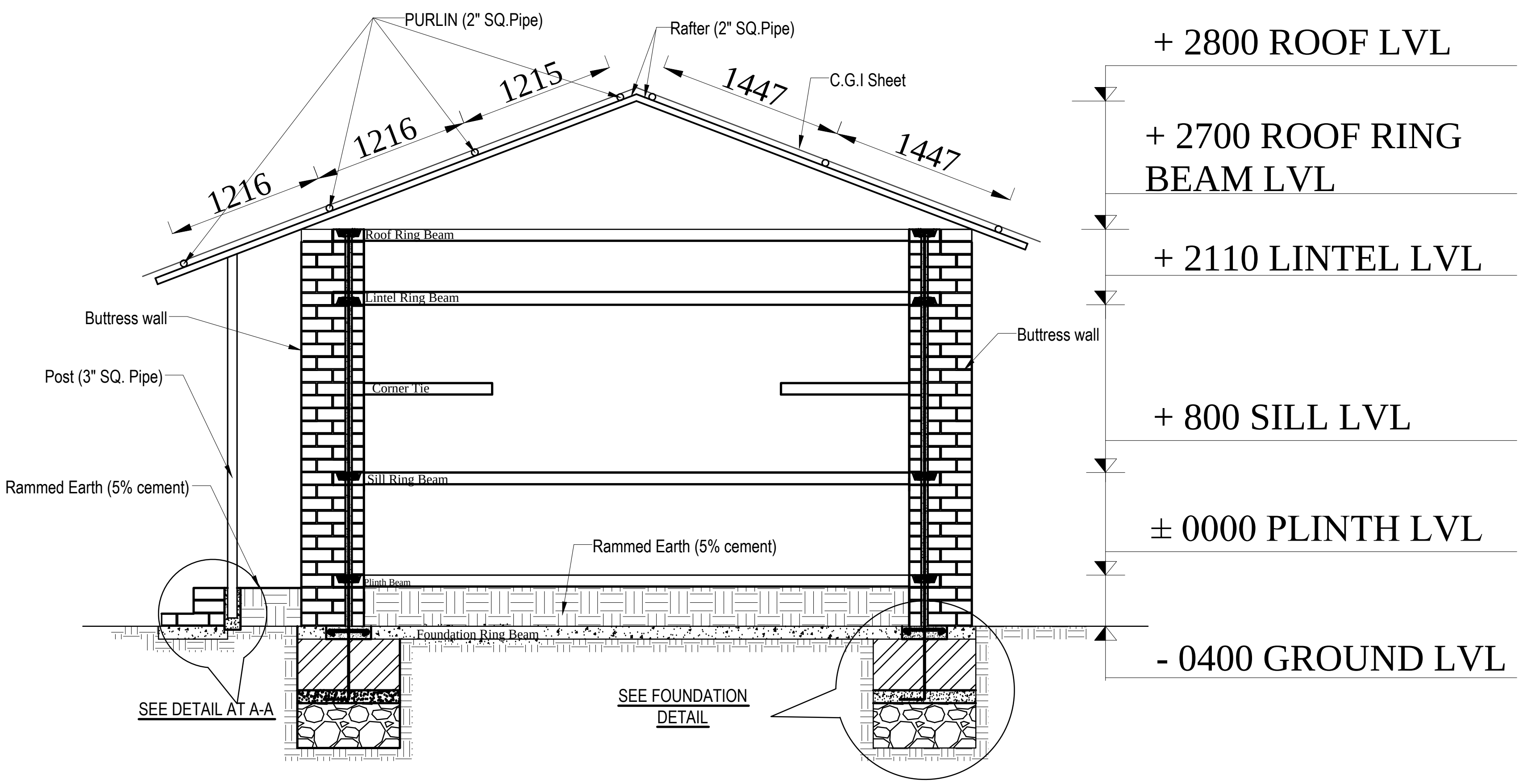
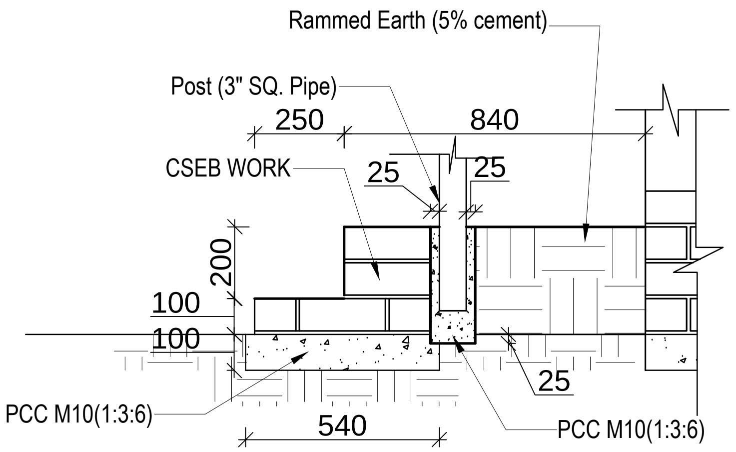
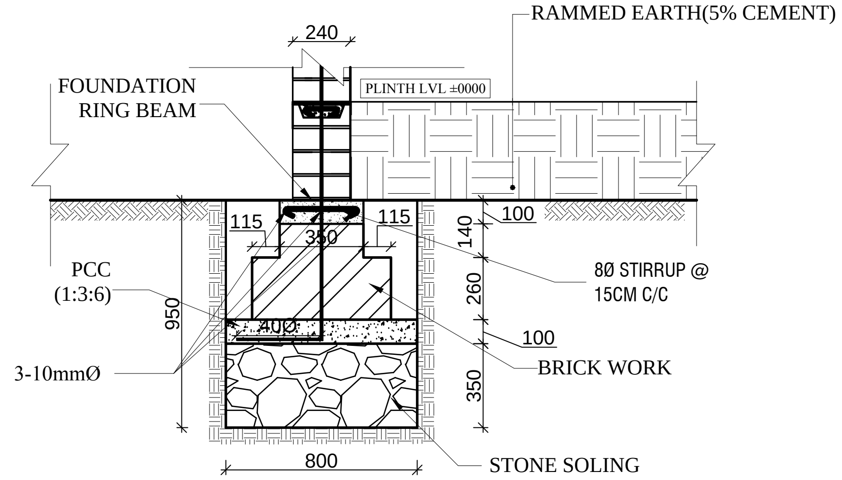
REV. 00				



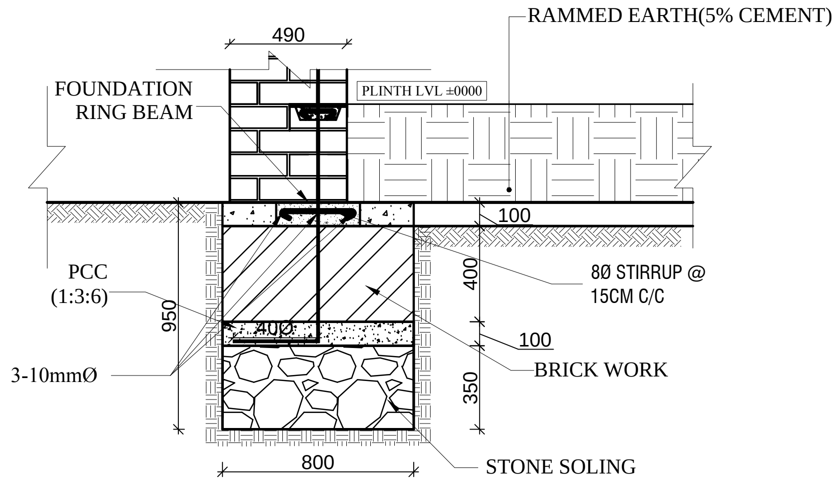
SECTION AT X-X



DETAIL AT A-A
SCALE 1:20

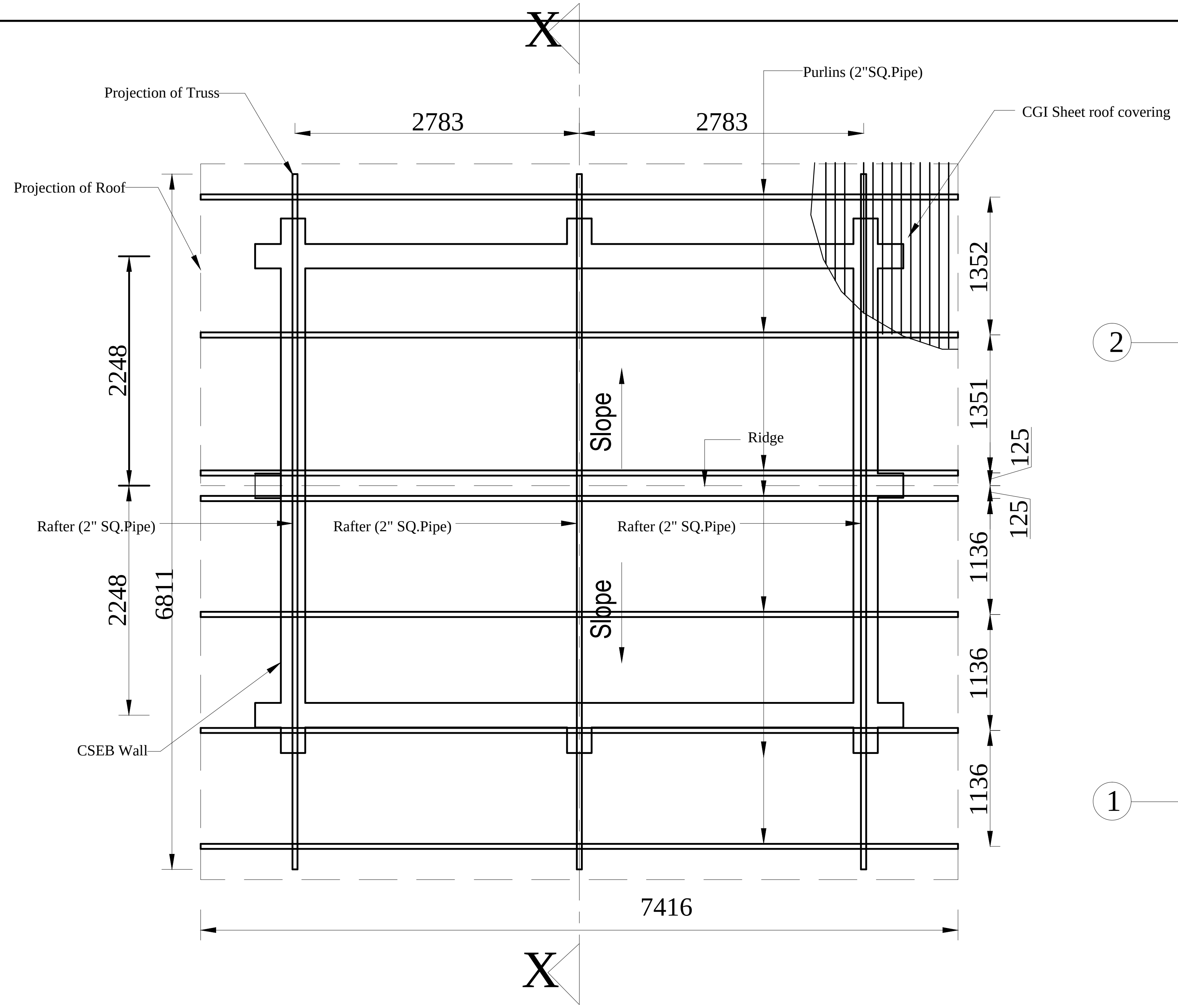


FOUNDATION DETAIL FOR WALL
SCALE 1:30

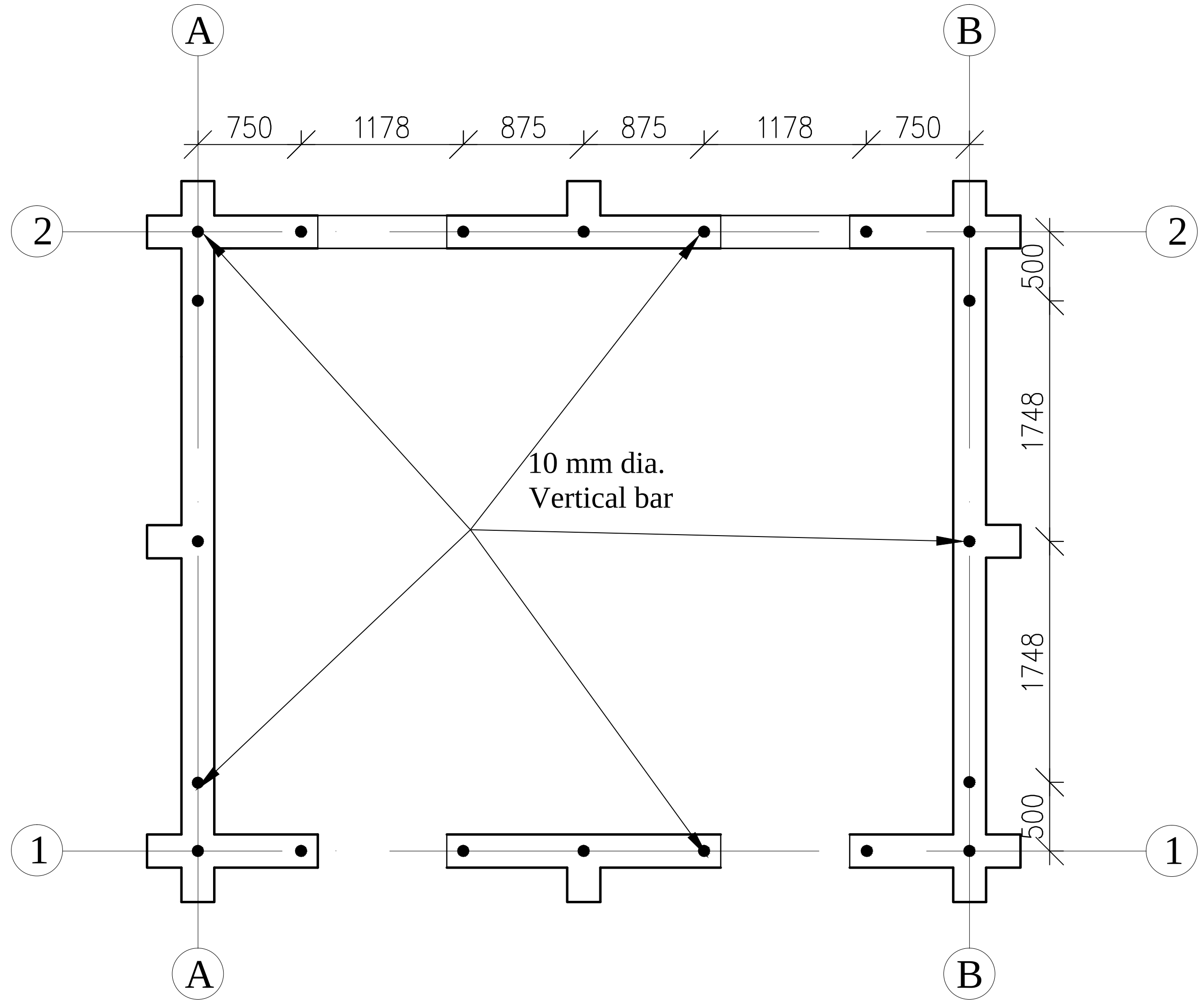


FOUNDATION DETAIL AT BUTTRESS WALL
SCALE 1:30

CENTER OF RESILIENT DEVELOPMENT Basundhara, Dhapasi G.P.O. Box: 1681, Kathmandu Email: info@cordvia.org उत्थानशील विकास केन्द्र CORD	PROJECT: PERMANENT SCHOOL DESIGN BLOCK MASONRY OF COMPRESSED STABILIZED EARTHEN BLOCK(CSEB)	SHEET TITLE: SECTION AND DETAILS	DRAWN BY: Er.Samrak Karmacharya APPROVED BY: Er. Hari Darshan Shrestha	DATE: Feb, 2016 SCALE: 1:50	DWG.NR. A-04 REV. 00	REV	DESCRIPTION HISTORY	BY	DATE	N



Detailing of Roof



DISTRIBUTION OF VERTICAL REINFORCEMENT
(with respect to Center Line)

CENTER OF RESILIENT DEVELOPMENT Basundhara, Dhapasi G.P.O. Box: 1681, Kathmandu Email: info@cordvia.org उत्थानशील विकास केन्द्र CORD	PROJECT: PERMANENT SCHOOL DESIGN BLOCK MASONRY OF COMPRESED STABILIZED EARTHEN BLOCK(CSEB)	SHEET TITLE: DETAILS	DRAWN BY: Er.Samrak Karmacharya APPROVED BY: Er. Hari Darshan Shrestha	DATE: Feb, 2016 SCALE: 1:50	DWG.NR. A-05 REV. 00	REV	DESCRIPTION HISTORY	BY	DATE

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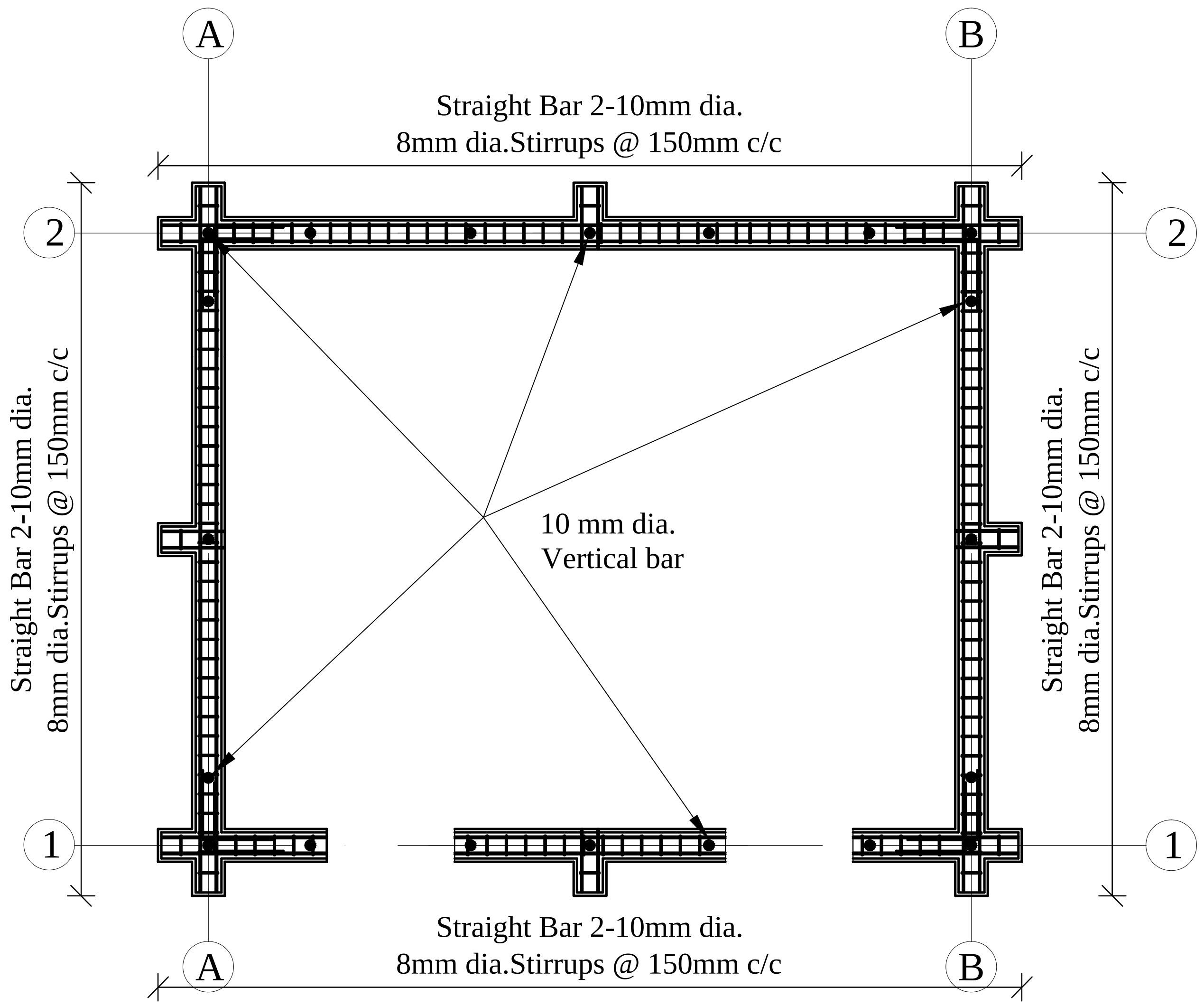
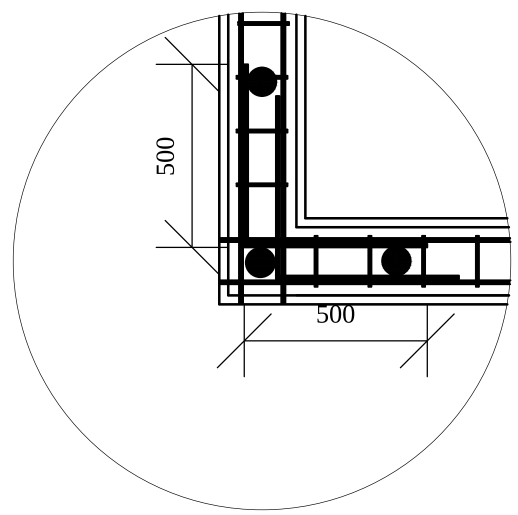
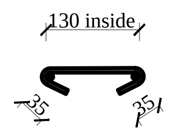


REINFORCEMENT DETAIL OF SILL RING BEAM



POSITIONING OF ANGLES AT L JOINTS

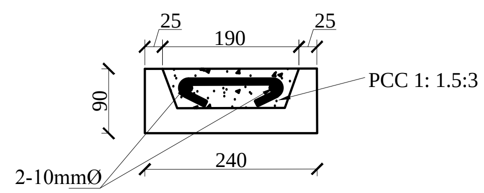
SCALE 1:20



STIRRUP DETAIL

SCALE 1:10

23 cm 8mmØ stirrup @ 15cm c/c



SECTION OF SILL RING BEAM

SCALE 1:10

CENTER OF RESILIENT DEVELOPMENT
Basundhara, Dhapasi
G.P.O. Box: 1681, Kathmandu
Email: info@cordvia.org
CORD

PROJECT:
PERMANENT SCHOOL DESIGN
BLOCK MASONRY OF COMPRESED STABILIZED EARTHEN BLOCK(CSEB)

SHEET TITLE:
DETAILS

DRAWN BY:
Er.Samrak Karmacharya

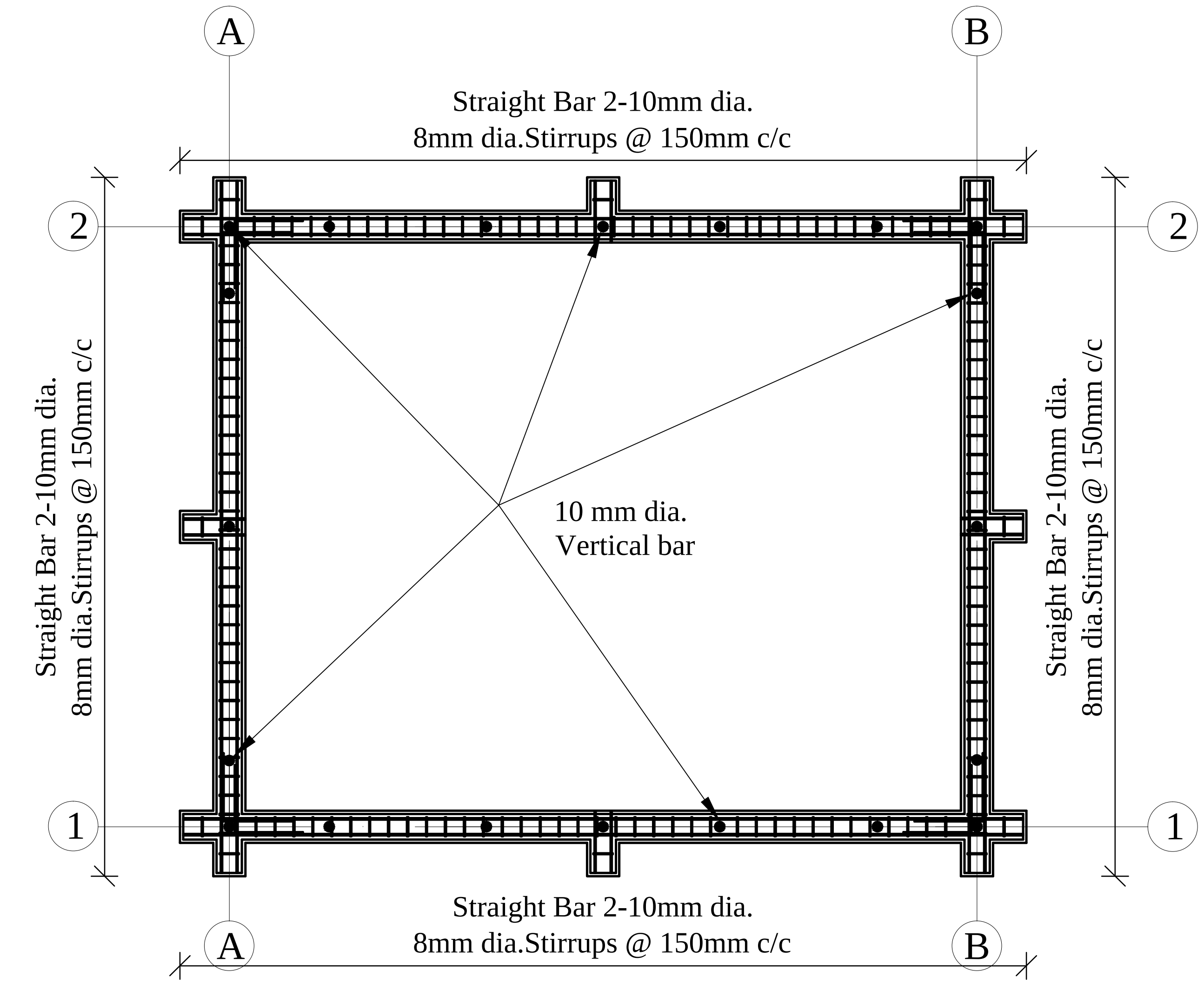
APPROVED BY: Er. Hari Darshan Shrestha

DATE:
Feb, 2016

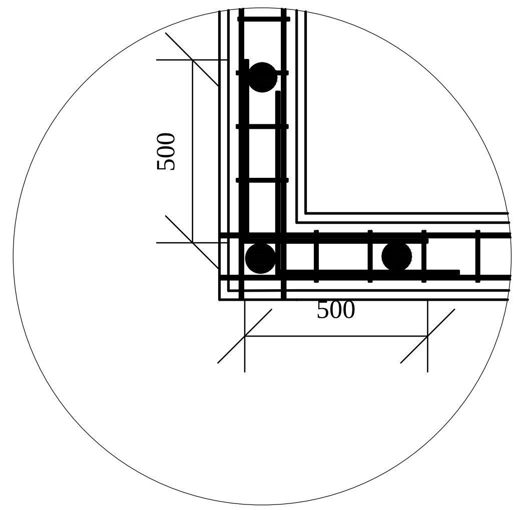
SCALE: 1:50

DWG.NR.	REV	DESCRIPTION HISTORY	BY	DATE
A-06				
REV. 00				

N

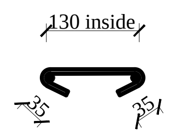


REINFORCEMENT DETAIL OF LINTEL/ PLINTH/ROOF RING BEAM



POSITIONING OF ANGLES AT L JOINT

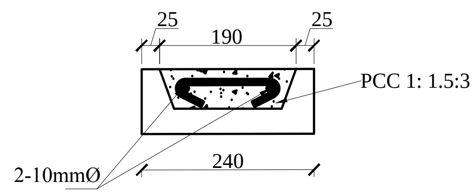
SCALE 1:20



STIRRUP DETAIL

SCALE 1:10

23 cm 8mmØ stirrup @ 15cm c/c



SECTION OF LINTEL RING BEAM

SCALE 1:10

CENTER OF RESILIENT DEVELOPMENT

Basundhara, Dhapasi
G.P.O. Box: 1681, Kathmandu
Email: info@cordvia.org

CORD

PROJECT:
PERMANENT SCHOOL DESIGN
BLOCK MASONRY OF COMPRESED STABILIZED EARTHEN BLOCK(CSEB)

SHEET TITLE:
DETAILS

DRAWN BY:
Er.Samrak Karmacharya

APPROVED BY: Er. Hari Darshan Shrestha

DATE:
Feb, 2016

SCALE: 1:50

DWG.NR.	REV	DESCRIPTION HISTORY	BY	DATE
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REV. 00				

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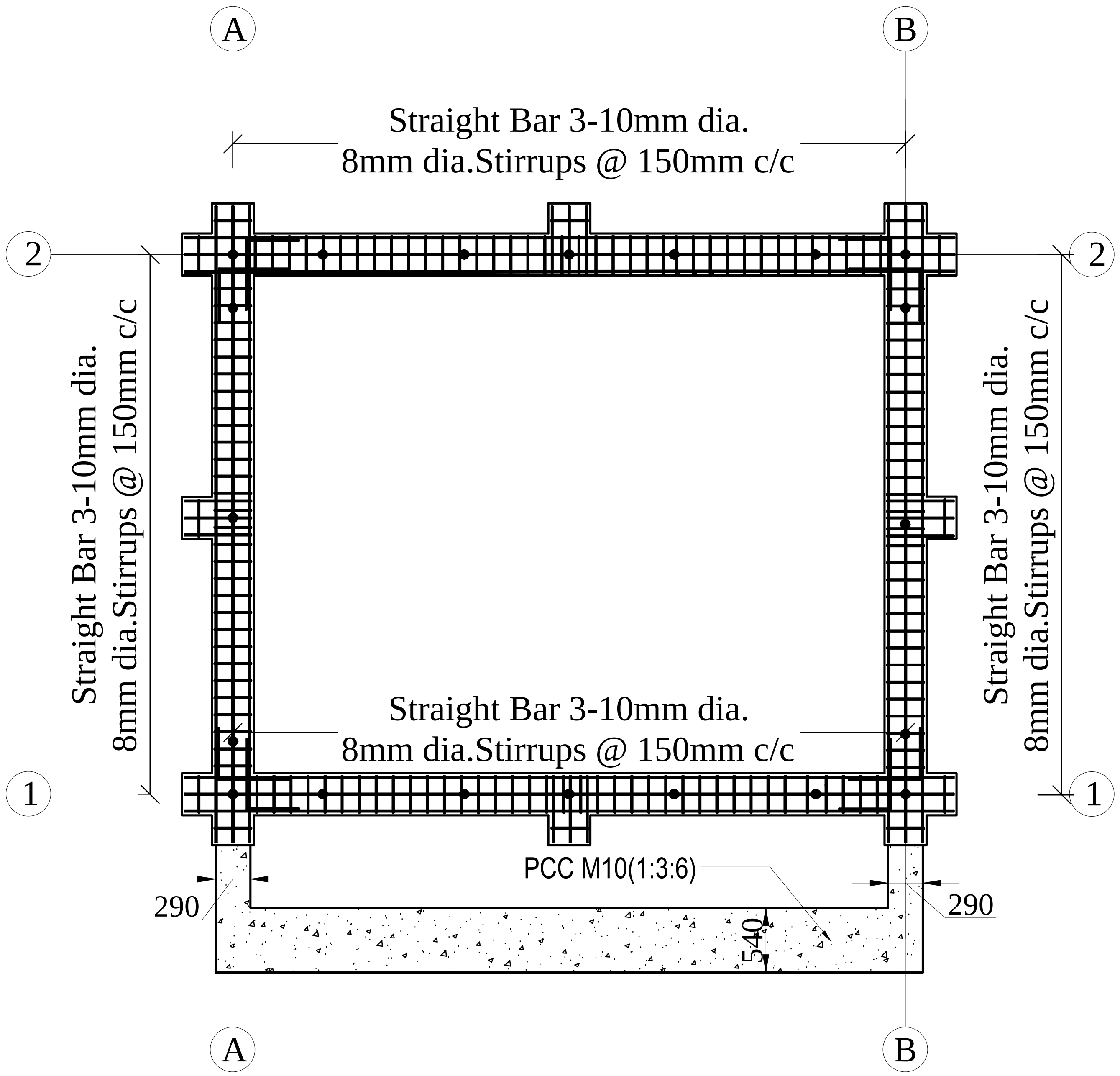
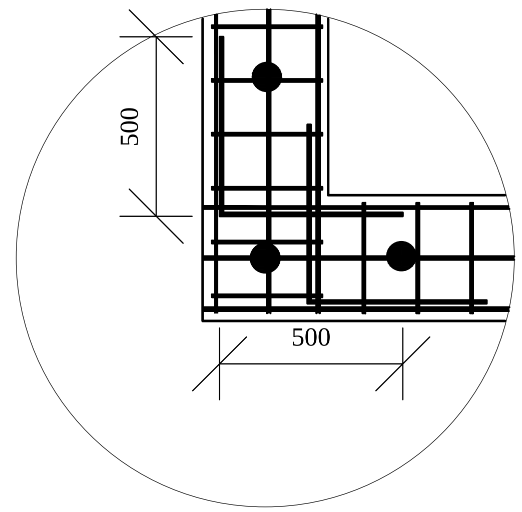
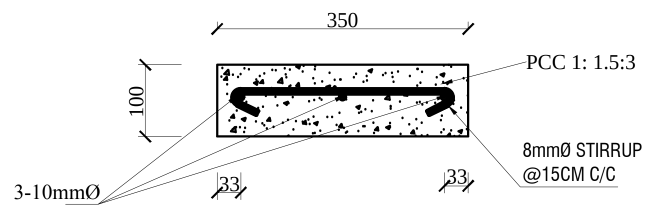


FOUNDATION RING BEAM LAYOUT PLAN



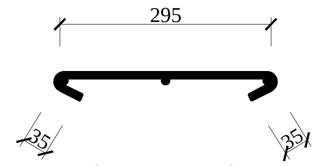
POSITIONING OF ANGLES AT L JOINT

SCALE 1:20



SECTION OF FOUNDATION RING BEAM

SCALE 1:10



STIRRUP DETAIL

SCALE 1:10

36.5 cm 8mmØ stirrup @ 15cm c/c

CENTER OF RESILIENT DEVELOPMENT

Basundhara, Dhapasi
G.P.O. Box: 1681, Kathmandu
Email: info@cordvia.org

उत्थानशील विकास केन्द्र
CORD

PROJECT:
PERMANENT SCHOOL DESIGN
BLOCK MASONRY OF COMPRESSED STABILIZED EARTHEN BLOCK(CSEB)

SHEET TITLE:
DETAILS

DRAWN BY:
Er.Samrak Karmacharya

APPROVED BY: Er. Hari Darshan Shrestha

DATE:
Feb, 2016

SCALE: 1:50

DWG.NR.	REV	DESCRIPTION HISTORY	BY	DATE
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REV. 00				

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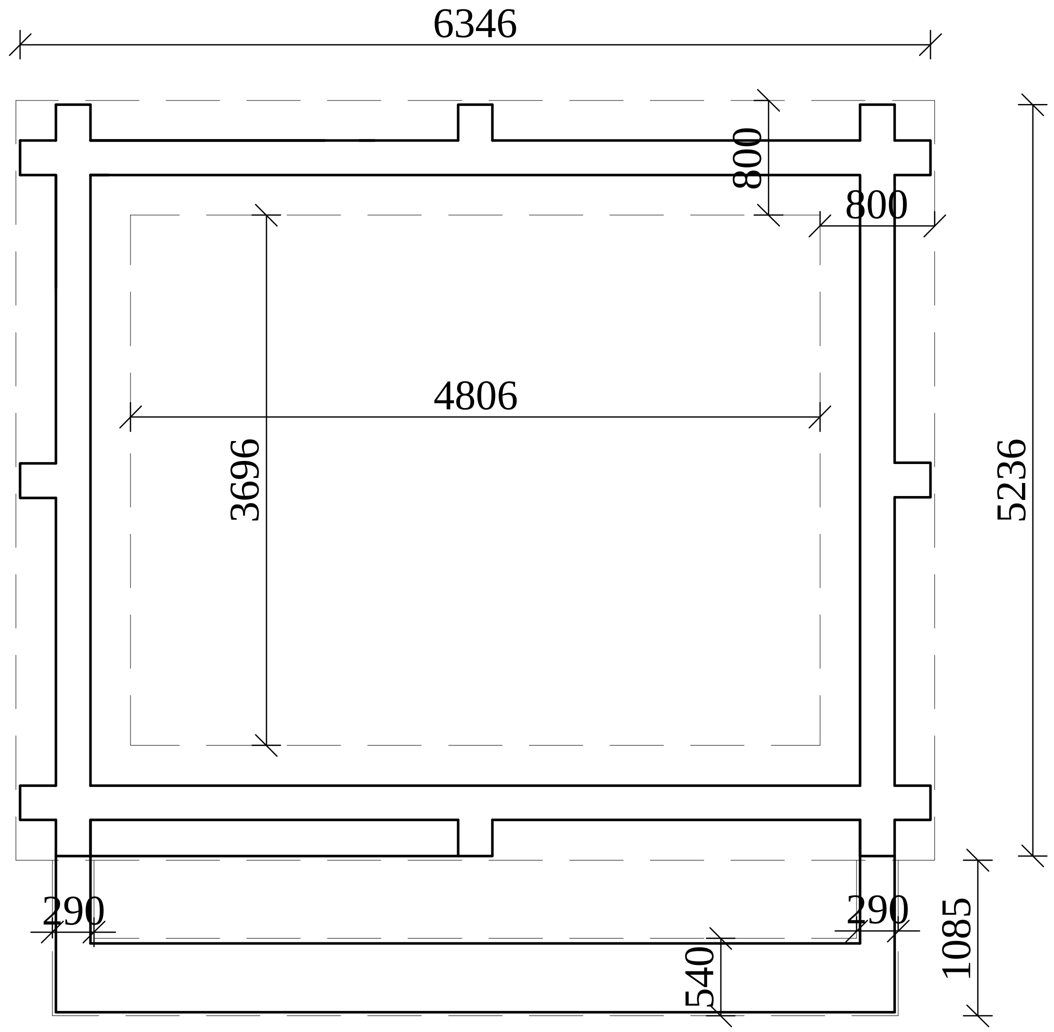


Trench Plan

CENTER OF RESILIENT DEVELOPMENT

Basundhara, Dhapasi
G.P.O. Box: 1681, Kathmandu
Email: info@cordvia.org

PROJECT:
PERMANENT SCHOOL DESIGN
BLOCK MASONRY OF COMPRESSED STABILIZED EARTHEN BLOCK(CSEB)

SHEET TITLE:
TRENCH PLAN

DRAWN BY:
Er.Samrak Karmacharya

APPROVED BY: Er. Hari Darshan Shrestha

DATE:
Feb, 2016

SCALE: 1:50

DWG.NR.	REV	DESCRIPTION HISTORY	BY	DATE
A-9				
REV. 00				

N

Bill of Quantities

Shelter Type: **School Design**

Block Masonry of Compressed Stabilized Earthen Block(CSEB)

				AS PER DISTRICT RATE		AS PER MARKET RATE			
Item No.	**Description of Works**	**Unit**	**Quantity**	**Rate**	**Amount (NRS)**	**Rate**	**Amount (NRS)**	**Difference(NRS)**	**Remarks**
1	Earthwork in excavation in foundations in gravel mix soil including dressing of sides, ramming of bottom and lead upto 10m, all complete as per drawing, specification and instructions.	Cu. M	15.61	628.26	9,807.14	750.00	11,707.50	1,900.36	
2	Stone filling with mud mortar in foundation in level, shape including transportation and supplying of materials, all complete as per drawing, specifications and instructions.	Cu. M	5.62	4,905.90	27,571.16	15,000.00	84,300.00	56,728.84	
3	Brick work in cement and sand mortar of mix 1:6 with chimney-made bricks, in any size and shape of wall, made to required line, level, shape and plumb including setting out, soaking of bricks, curing of the works and scaffolding, etc. complete as per drawing, specification and instructions.	Cu. M	4.01	14,332.64	57,473.89	15,000.00	60,150.00	2,676.11	
4	Local flat brick soling work with sand filling all complete as per drawing, specification and instructions.	Sq. M	7.59	969.56	7,358.96	3,500.00	26,565.00	19,206.04	
5	Plain Cement Concrete (PCC) of Grade M10 (1:3:6) in any form, size, shape and level for foundation including mixing, laying, compacting, curing, testing and finishing, complete as per drawing, specification and instructions.	Cu. M	1.96	11,399.95	22,343.90	12,000.00	23,520.00	1,176.10	
6	Plain Cement Concrete (PCC) of Grade M20(1:1.5:3) in any form, size, shape and level for foundation ring beam including mixing, laying, compacting, curing, testing and finishing, complete as per drawing, specification and instructions.	Cu. M	0.81	13,257.78	10,738.80	20,000.00	16,200.00	5,461.20	
7	Rammed earth(5% cement) in between foundation and plinth level including transportation and supplying of materials, all complete as per drawing, specifications and instructions.	Cu. M	10.42	210.12	2,189.45	10,000.00	104,200.00	102,010.55	
8	Providing, fitting and fixing formwork including dismantling and transporting after concrete is set up to distance of 30 m all complete as per drawing, instructions.	Sq.M	15.01	1,345.75	20,199.71	1,000.00	15,010.00	(5,189.71)	
9	Plain Cement Concrete (PCC) of Grade M20(1:1.5:3) in any form, size, shape and level including mixing, laying, compacting, curing, testing and finishing, complete as per drawing, specification and instructions.	Cu. M	2.62	13,257.78	34,735.38	20,000.00	52,400.00	17,664.62	
10	Tor steel reinforcement bar of fe 415/500 grade of 10mm diameter including supplying, straightening, cleaning, cutting, binding & fixing in position with annealed tying binding wire as per drawing, design & instruction all complete.	Kg	257.19	117.40	30,194.11	125.00	32,148.75	1,954.64	
11	Tor steel reinforcement bar of fe 415/500 grade of 8mm diameter @ 8" c/c for stirrups including supplying, straightening, cleaning, cutting, binding & fixing in position with annealed tying binding wire as per drawing,	Kg	65.05	113.72	7,397.49	125.00	8,131.25	733.76	
12	Providing and laying CSEB wall in cement/ sand (1:5)mortar with both side fair finish including cost of scaffolding, filling and raking out joints wherever required as per drawings, specifications and instructions.	Cu.M.	17.75	10,281.56	182,497.69	15,000.00	266,250.00	83,752.31	
13	Local high strength wood work in any level, size and shape for Door, Window, as required all complete as per drawing, specification and instructions.	Cu. M	0.24	84,381.46	20,251.55	125,000.00	30,000.00	9,748.45	
14	Local high strength wood work in any level, size and shape for door, window frame as required all complete as per drawing, specification and instructions.	Cu. M	0.14	108,369.86	15,171.78	125,000.00	17,500.00	2,328.22	
15	Installation and positioning of C.G.I sheet work in roof in level all complete as per drawing, specification and instructions excluding transportation charge.	Sq. M.	51.99	989.43	51,440.47	1,500.00	77,985.00	26,544.53	
16	12.5mm thick cement-sand plaster in any level size and shape of wall as required including racking, plastering to level, smooth etc. all complete as per drawing, specification and instructions.	Sq. M.	156.87	372.60	58,449.76	750.00	117,652.50	59,202.74	
17	Two coats of Emulsion paint to plastered surface of any shape, size and height with specified paint of approved shade inclusive of surface preparation by providing putty and sandy surface, watering (if necessary) cleaning.	Sq. M.	156.87	161.03	25,260.78	550.00	86,278.50	61,017.72	
18	Providing, fitting and fixing truss including transportation all complete as per drawing, instructions.	M	80.87	497.00	40,192.39	1,000.00	80,870.00	40,677.61	
19	Holdfast	Nos	20.00	30.00	600.00	150.00	3,000.00	2,400.00	
20	Hinge	Nos	14.00	45.00	630.00	50.00	700.00	70.00	
21	Handle	Nos	8.00	25.00	200.00	350.000	2,800.00	2,600.00	
22	Cheskini	Nos	8.00	45.00	360.00	175.00	1,400.00	1,040.00	
23	Lock	Nos	2.00	200.00	400.00	350.00	700.00	300.00	
TOTAL					**625464.395**		**1119468.500**	**494004.105**	

Annex 3: Technical Guideline for construction of GI contained stone masonry with mud mortar and CSEB Construction

'Technical Guideline'

Earthquake Resistant House of Stone and mud with GI Wire Containment Reinforcement for Nepal

Introduction:

In hilly areas of Nepal and India most of the houses are built with stone and earth. These buildings have suffered extensive damage during earthquakes. Because of this many engineers are advocating the use of bricks, cement and steel rods. But in the remote mountain areas it is difficult to bring these materials, and people have plenty of stones and earth available for construction.

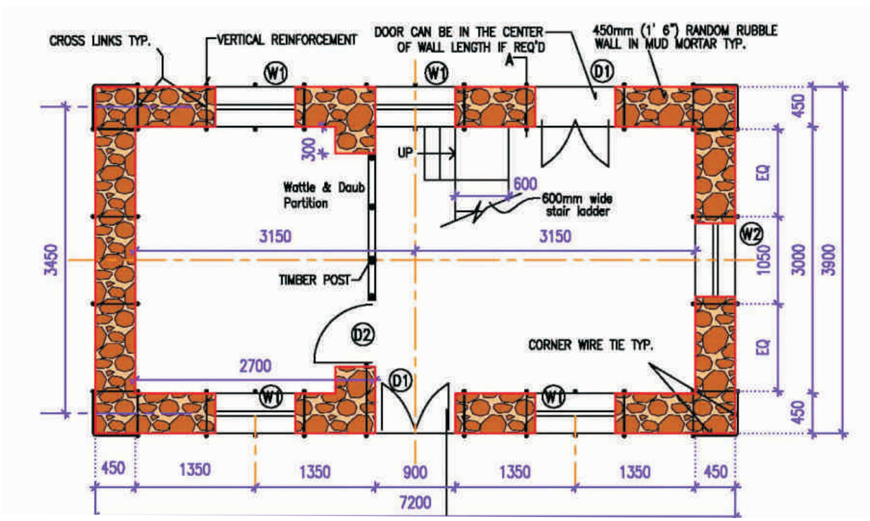
Before deciding on what to use one must understand why these stone houses collapsed. The studies of damage show that stone was not responsible for the damage, but it was the way stones were used. Damage does not occur because of a material. Even brick, cement and steel structures also can collapse if they are not constructed according to the basic rules of construction.

So people can build with stone, but they must follow all the basic rules. To make the house strong against earthquake GI wires containment along with weld wire mesh (WWM) bands can be used. With this there is no need of cement or steel bars. If this is done then it is possible to prevent the collapse of your house. So get ready to build an earthquake resistant house that you can afford.

You can build a single story house right now. Later at any time if you need to construct another storey above then remove the roof, extend the attic wall up to 8' height along with the wire reinforcement. The timber wall plate must be reinstalled on the new top and anchored to wall with wire reinforcement. The roof can be reinstalled.

Construction sequence for an earthquake resistant stone - mud house

This one and a half storey structure consists of one 7200 x 3450 large living space and a 7200 x 3450 attic space using entirely local materials like stone and mud for walls, Corrugated Galvanized Iron (CGI) sheeting on timber under structure for roof, and mud flooring on timber deck for intermediate floors which are no different from the most common houses in the hills of Nepal. The basic design is based on the National Building Code 203 of Nepal. But the earthquake resisting system consists of vertical containment wires anchored on both faces of all the walls starting from near the ground to the top of attic parapets, and several horizontal bands made of Weld Wire Mesh (WWM) placed in mud mortar. Dependence on only GI wires and WWM results in simple logistics even in remote places and makes the system doable, and within the reach of most home owners. It is important that the people understand the rules of good quality masonry and of Containment Reinforcement System. With this the people will be able to ensure their safety in new houses that suite their lifestyle and are made of stone, earth and timber with the help of local artisans.



House Plan and Location of Cross-links

1. Basic rules of random rubble stone masonry construction (Cont.)

Never use round stones for masonry. They are slippery. Wall made with them is unstable. Round boulders must be broken to get angular faces for use in wall masonry.

Use angular stones that are often found on the mountain side and in gullies. Get stones that are of right size for 18" thick walls.

Use plumb bob and string line for each course of wall masonry

Use stone chips to fill gaps between stones instead of mortar. Never fill with round stones. Every course does not have to be leveled.

Width of the wall shall be not less than 350mm (15") and not more than 450mm (18").

Place stones longer than the thickness of wall in the corner for strong wall to wall joint

1. Basic rules of random rubble stone masonry construction (Cont.)

Break all vertical and horizontal joints in masonry

Orient length of each stone in to the thickness of wall to ensure interlocking of inside and outside faces of wall.

Both faces must lock with each other to form one wall. Vertical joints must break.

Provide “through-stone” one in every 0.7 sq.m. and arrange in zig-zag pattern.

Looking at a wall from above the joint between the stones in the wall should not be in a straight line, bust must be broken.

1. Basic rules of random rubble stone masonry construction (Cont.)

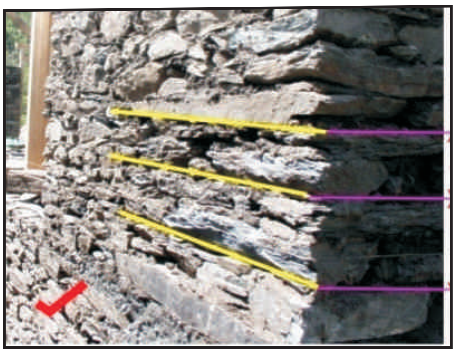
Place each stone flat on its broad face.

Construct all walls at the same time. If not possible then leave the wall end in stepped manner.

Never build corners first with toothing and then fill up the gaps between the corners. Construct corners and walls together.

Each stone must be in contact with the stone under it, with little or no mud mortar in between.

Never mix different masonry materials at the same level in a building.



Random rubble masonry must be done in courses of height no more than 600mm.

2. Excavation for Foundation

Following the rule of 3:4:5 or 9:12:15 to get 90º angle at each corner, mark the center line of the foundation trench. Both diagonals must be of equal length.

Drive 2 pegs in ground at 600mm (2'-0") away from each of the centre line corners so that the excavation does not disturb them. In all, there will be 8 pegs, 2 at each corners.

Mark out the inner and outer foundation lines from center line (1'-3”on either side) to create 750mm (2'-6”) wide foundation trench lines.

Dig trench 750mm wide and 750mm deep (2'-6” wide and 2'-6” deep). Dig extra for buttresses in the long walls on the inside or outside face.

Remove all the dirt and loose soil. Make sure there is no water in the trench. Compact the bottom of the trench with hand ram.

3. Foundation Masonry

In the foundation below ground do not use round stones, and do not just dump stones.

In foundation below ground the stones must be placed as per good quality masonry rules.

Construct stone masonry foundation base in full width of the trench 750mm wide and 150mm high in mud mortar.

Use right size angular stones.

Construct foundation wall 550mm thick with steps as per the drawing up to 75mm above the ground level .

Continue wall construction up to 75mm (3") above ground level.

4. Cross-links

While the foundation masonry construction is going on, using 2-14 ga. GI wires make 600mm long cross-links with middle 450mm twisted.

Making GI wire cross links.

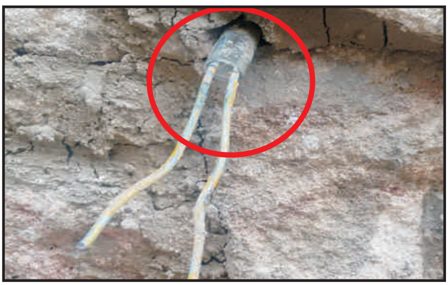
GI wire cross links with open ends .

Attention: When the plinth wall reaches 75mm above ground level stop construction to install the first set of cross-links.

Cross-links be given extra protection against water rising from ground by placing them within PVC tubing (used for "tube-level" in construction).

At min.75mm above ground level place GI wire cross-links on the stone wall with open ends projecting out from both the wall faces.

The location of cross-links to be as per cross-link location plan and spacing max.900mm. between two cross-links.



M-Seal, or equivalent could be used to seal the open ends of tubing after containment wires are installed for ensuring protection against water.

5. Construction of Plinth Masonry with Plinth Band

Construct 450mm (18”) thick plinth wall in mud mortar above foundation masonry up to minimum 450mm height above the ground level.

Lay thin plastic sheet 450mm wide at that level as damp proof course (DPC). Cover it with thin layer of mud mortar on top to reach the floor level.

Place galvanized, or paint coated WWM strap 350 mm wide centrally on the wall with 50mm clear cover along both faces to make band.

At wall junctions install extra piece of WWM at 45 degrees to strengthen corner connection between WWM straps using GI binding wire.

Attach the GI wire cross-links on top of the WWM band exactly above the lower cross-link with GI binding wires at three locations .

The cross-links must be in plumb above the lower cross-links.

To allow the installation of the containment reinforcement on wall faces, do not back fill plinth and ground all around to keep cross-links exposed until the masonry is complete

Put 25mm thick layer of mud mortar on top of WWM. This is the plinth or the finished floor level, which should not be less than 450mm from ground level.

6. Door Frame Installation

Install the door frame at the location marked on the plan. All timber should be coated with used engine oil mixed with kerosene.

Each vertical post should have minimum two hold-fasts for strong connection with the wall. Ensure that the frame is in plumb in all directions. Secure each door frame with slant timber props so that it does not move.

7. Construction of Walls from Plinth to Sill Level

Construct 450mm (18”) thick stone walls in mud mortar up to 450mm (1' 6”) above Plinth level. Place next set of GI wire cross-links and 900mm long WWM straps in all corners on top of the wall

Continue up construction of wall for 450mm (1' 6”) more, thus reaching total wall height of 900mm (3' 0”) above the Plinth level. Install WWM band along with the cross-links .

8. Construction of Walls from Sill Level to Lintle Level

Install window frames where required. Leave the space for window opening if frame is not on hand.

Continue the construction of wall up to lintel level at 1800mm (6' 0") above plinth level along with cross-links at 1350mm (4' 6") height.

Put timber lintel over the door and window openings (with or without frame) with minimum 255mm (9") bearing on wall at both ends.

On top of the lintels place WWM band with cross-links. Follow all the instructions given earlier for the Sill level band.

Construct wall above the lintel level band up to 2250mm (7' 6") height. Place the WWM band with cross-links at this level as done before. Place 25mm mud layer on the top of WWM band.

Installation of main Timber Post in Ground

Dig 150mm (6”) diameter hole 450mm (1'-6”) deep in compact ground for main timber post at suitable location in the building.

Apply coal tar (or burnt engine oil plus kerosene) on the portion of the post which will be inserted in the ground.

Cover that portion in thick polyethylene tightly tied with plastic string.

Prepare seat on top end of the post with knee braces before erecting the post.

Insert the post in hole in the ground. Place the floor beam above and attach it to post metal strap and nails.

Similarly prepare the post with a seat for ridge beam in the attic and install the post right above the post of the lower storey.

9. Installation of Timber Floor - Improvements in Traditional Floor

Install cut timber wall plate on all walls on top of the WWM band along the outside face of the wall.

Place timber joists at same level as the wall plate, abutting the wall plate and connect them to the wall plate.

Tie wall plate – floor joist assembly to the WWM band with 2mm GI wires at all floor joist locations.

10. Construction of Attic Wall

Continue wall construction above the attic floor with its height no greater than 900mm (3' 0").

Place cross-links at the mid height of parapet wall, and WWM band with cross-links on top of the parapet wall.

On top of floor joists place planks and then flooring such as earth flooring.

Provide struts and GI wire diagonal bracings on underside of the floor.

11. Installation of Timber Wall-Plate Assembly on the Attic Wall

Prepare all parts of wall plate assembly using round or cut timber and apply used motor oil and kerosene mixture on all timber.

Make the wall plate assembly on top of the wall or on the ground with short timber pieces attached at location of containment wires in the walls.

Wall plate assembly with 375mm (15”) long timber pieces (end in line with the inside face of the wall) connected with packaging metal straps and nails.

At all corners install diagonal stiffeners to improve the corner assembly

Make proper lap joints for better connections and use packaging metal strap for all timber to timber joints

12. Installation of Vertical Containment Reinforcement

From each cross-link in the bottom most row on both faces of each wall attach 1-4mm diameter GI wire or 1-6mm diameter aluminum wire to go over the top of the attic parapet wall.

Stretch the wire up, pull it to straighten it, and starting from plinth, anchor the wire to the wall using each of the cross-links on both faces.

Use pair of pliers to twist the free ends of cross link not more than 4 times. Bend down or up the extra length of cross link wires.Do not miss any cross-link

For proper positioning of the vertical wires, shallow grooves may be made in the wall plate and wood stubs so that the wire remains within the groove and does not shift one way or another.

Pull the wire along the outer face of wall over the attic wall, and over the wall plate, and anchor it to the wall plate stiffener with a heavy nail. Similarly, pull the wire along the inner face of the wall over the wall top and anchor it to the wall plate.

Installation Roof of Rafters and Purlins - Improvements in Traditional Roof

Install rafters with one end on ridge beam and the other on the wall plate and fix them with GI strip and nails.

Rafter and wall plate connection.. Always use hand drill for making pilot hole before nailing for all timber joints.

Install purlins on each side of the roof with nails. Using spirit level or tube level ensure that all the purlins (batons) are level between the ends.

If round timber is used for rafters use packing under purlins to keep it level by compensating for the unevenness of the timber.

Purlins should be securely anchored to the rafters and wall plates using metal straps or GI wires in addition to nails.

Installation of CGI sheet roofing

Install CGI sheets on purlins with 3” of overlap on consecutive sheets. Before attaching sheets make sure the overhang of roof over both support walls and at ends is adequate.

Use J hooks along roof periphery with flat metal and tarfelt washer to attach sheets to purlins. At all other locations $2^1/_2$” nails with flat metal and rubber washer may be used.

Install GI sheet on ridge to seal the gap between the CGI sheets on the opposite sides with min. 6” overlap.

The triangular gables should be closed with tin sheet or wood planks.

Part of the triangular portions in the end walls in attic can be covered with metal mosquito netting to permit lighting and ventilation.

Include of buttress to stabilize the long wall against earthquake forces.

Finishing walls

Remove all mud mortar stuck to wall surface and clean the wall.

Hammer in small stone chips in all the gaps in masonry joints. Finish door threshold and window sills with cement mortar.

Finish inside walls with mud mortar covering vertical wires.

Do not cover vertical wires with cement or mud mortar, or else it will corrode fast.

GI Wire Containment technology can really bring safety

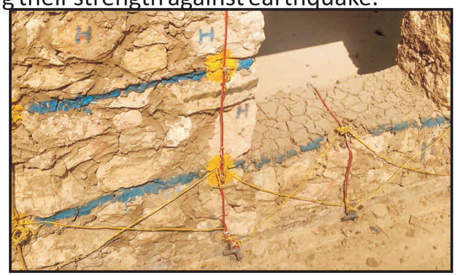
Two models made on a table with wheels were given 14 powerful shocks by hitting the table with a 1,500 kg pendulum.

First model of $1\,^{1}/_{2}$ story suffered much damage because of poor masonry and inadequate reinforcement.

Second model of $2\,^{1}/_{2}$ story with better masonry and more reinforcement suffered very little damage.

13. Rules of Containment Reinforcement System

- Cross links are to be of 2-14 ga (2mm) galvanized iron wires placed at 450mm (18") vertical spacing.
- All Cross links below ground will be of aluminum wires.
- When wall length is twice the height, or more, then it is considered as "Long Wall", otherwise it is considered as "Short Wall".
- The maximum spacing for vertical reinforcement of 4mm GI wires, or 6mm aluminum wires on inside and outside faces in "Long Wall" is 900mm (3') and in "Short Wall" it is 1,200mm (4'). All wires if taken below ground are to be of aluminum.
- All vertical reinforcement is to be anchored walls with Cross links placed in the walls.
- Bands at Plinth, Sill, Lintle, Floor and Eave levels are to be 350mm wide with 50mm clear cover along both faces. All Seismic Bands are to be made of Galvanized Iron (GI) 14 ga (2mm) Weld Wire Mesh having 12 longitudinal wire at approximately 31mm spacing placed in mud mortar. In case of different gauge or spacing of longitudinal wires ensure equivalent steel cross-section area. If not GI then protect the WWM with a coat of Red Oxide.
- Diagonal ties on wall faces are to be 1-14 ga (2mm) GI wire tied between Cross links on inside and outside faces. .
- Corner ties on wall corners are to be 1-14 ga (2mm) GI wire tied around wall face between Cross links nearest to the corner.
- All binding wires used for connection with WWM are to be galvanized.
- In case of the existing foundation provide cross links at 75mm above ground by removing parts of plinth.
- All timber to timber connections are to be strengthened using 14 ga GI wires or packaging metal straps.
- Make buttresses in long walls for improving their strength against earthquake.



14. A few words on the technology

In the hilly areas where the access is difficult carrying in of heavy and bulky materials like cement bags and steel bars is generally not feasible due very high transportation and head-load costs. Availability of large quantity of water needed by cement also poses a major hurdle. Alternate that is given here is simple and easy to execute. It is viable since it is aimed at improving the performance of the traditional construction in Himalayan foothills that includes random rubble masonry in mud mortar, floor deck and roof frame. The approach is based on the adherence to the basic principles of good construction. The seismic resistance is provided by the containment wires anchored on the inside and outside wall faces along with WWM bands.

House design by NCPDP with support from UNDP- Nepal

NCPDP-CEDAP

National Centre For People's - Action In Disaster Preparedness.
(NCPDP) INDIA Tel : 079 - 2630 0970, Fax : 079 - 2630 8843.
Email : mitigation@ncpdpindia.org, Website : ncpdpindia.org

United Nations Development Programme, Nepal

UN DP

'Technical Guideline'
CSEB as Construction Material for Earthquake Resistant Houses for Nepal

1. Introduction

The April 25 earthquake and its aftershocks specially of May 12, 2015 caused unprecedented destruction in Nepal with about 9,000 casualties, over 22,000 injuries along with complete destruction of more than half a million housing units and various level of damages to more than 250,000 buildings (PDNA, NPC 2015). The Government of Nepal has expressed its resolve to support the affected communities to reconstruct their houses with improved and affordable technologies for creating disaster resilient communities. The Nepal Earthquake Recovery and Reconstruction Policy have rightly focused on ensuring reconstruction of disaster resistant houses.

The earthquake hit hilly rural areas of Nepal, most of the houses are built with stone in mud mortar while in urban and semi urban areas, burnt brick and cement concrete are used for construction. The Rapid Visual Damage Assessment revealed that more than 80 percent building collapsed are non engineered in rural areas constructed with traditional materials like earth, stone, bamboo, wood. This lead to building up of a common perception that houses built with 'traditional materials' like earth, bamboo or stone are weak, but the one built with 'modern materials' like cement, concrete and steel are strong. Though this perception is totally misplaced, it is very hard to convince the local community to use the same material for reconstruction of their houses. On the other hand availability of stone and wood has become limited and efforts to quarry stones and wood will have higher environmental consequences. Similarly, the low affordability of nation as well as individual does not give liberty for the use of modern construction materials and technologies.

In this context a low cost construction material like CSEB (compressed stablized earthen block) which has been tested across the globe if blended with earthquake resistant technologies can result into earthquake resilient community with the given resources. Further, the CSEB will have other added benefits like: climate resilient, environment friendly, in situ casting and support to local economy. So get ready to build an earthquake resistant house that you can afford.

2. Production of CSEB (Compressed Stabilized Earthen Block)

The construction of CSEB starts with selection of tools and soil for production of bricks at local level. The tools required are locally available tools used in building construction except the 20 ton manual soil compressor machine.

Aurum 3000 machine is hand press machines. The machine consists of a frame, an interchangeable mould and reverse toggle lever. Other accessories include scoops and bottom plates. The machine is mounted on the ground and secured in position using sand bags or stones. Measured quantity of this mixture is poured in the die of predefined shape and dimensions and is compressed by pulling the lever by hand. Then the compressed block is ejected from the die. The wet compressed blocks are stacked in rows.

Special Features of Aurum press 3000:

- High output from the automatic opening: 300 to 400 strokes/day.
- **= 40 to 50 Blocks/Hour (plain full size blocks)**
- Handling of the press with 3 men. Mix preparation and block stacking with 4 men.
- High and adjustable compression ratio from 1.6 to 1.83 (1.77 for 9 cm height)
- Micro adjustment of compression ratio
- Double compression with the folding back lid.
- Rollers to move the press on site. Only 2 men are needed.
- Block height adjustable with ring spacers**:** **2.5 cm and from 5 to 10 cm.**
- Micro adjustment of block height: 0.5mm accuracy.
- Interchangeability of moulds
- Moulds are provided for making 4/4, 3/4 & 1/2 sizes.
- Self-stability with the adjustable braces.
- Very easy maintenance with grease nipples and grease gun.

Fig 1: Auram 3000 Compressor

The CSEB production is illustrated by the cycle presented below:

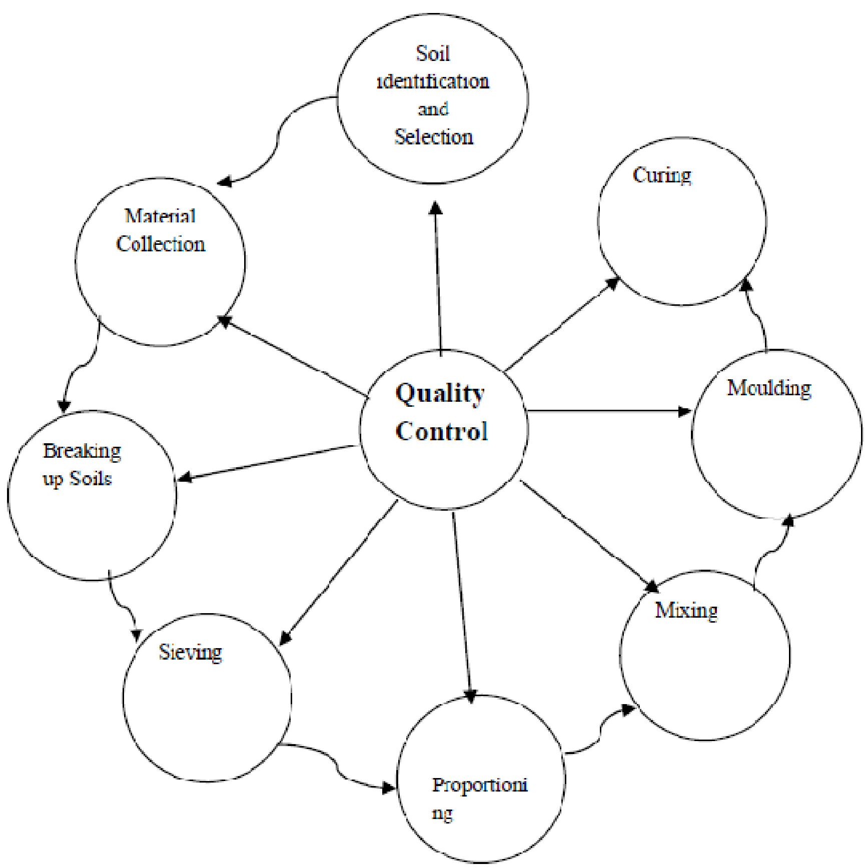
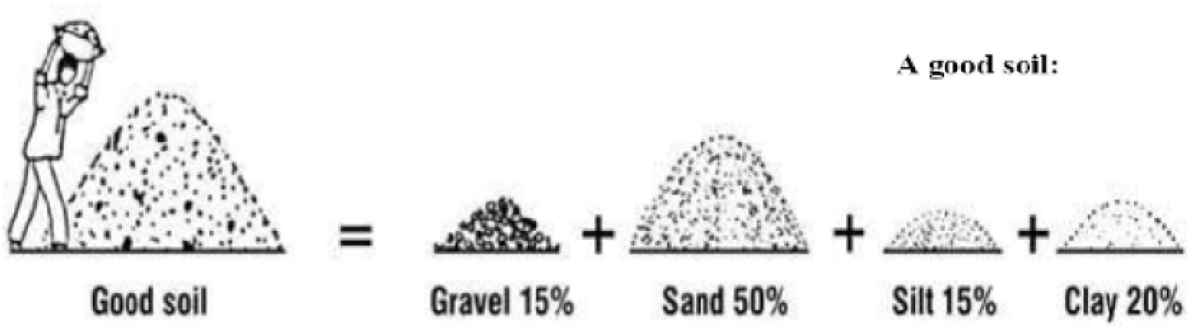


Fig 2: CSEB Production Cycle

2.1. Selection of Soil

Materials required for casting of bricks in situ are collected and stored at site. The materials required include sand, cement, iron bars and soil dug after removing the top layer. The soil lumps are broken to make it uniform such that it could pass through the 5mm sieve.

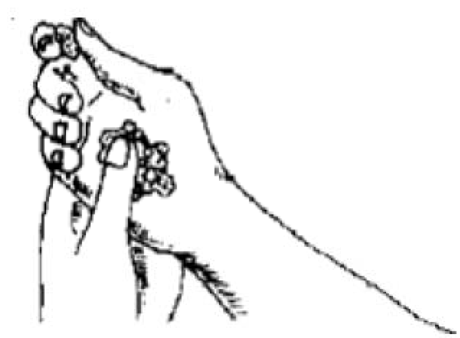


2.1.1. Soil Test

Simple tests could be done at site to find out the type of soil. It will give an idea whether sand need to be mixed or not. The tests include

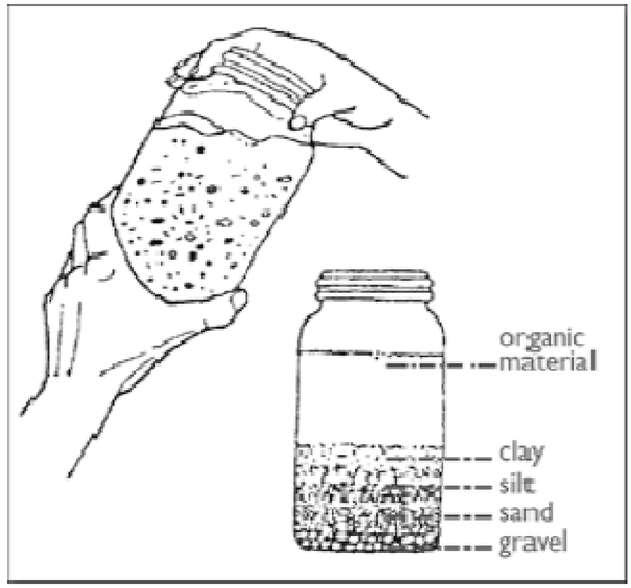
Touch test

After removing the largest grains, crumble the soil rubbing it between the fingers and the palm The soil is sandy if a rough sensation is felt and has no cohesion when moist. The soil is silty if it gives a lightly rough sensation and is moderately cohesive when moistened. The soil is clayed, if, when dried, contains lumps or concretions which resist crushing and if becomes plastic when moistened.



Sedimentation Test

To obtain a more precise idea of the nature of each soil fraction, a simplified sedimentation test can be carried out in the field. The apparatus required is a transparent cylindrical glass bottle with a flat bottom and a capacity of at liter with a neck wide enough to get a hand in and a lid to allow for shaking.



Fill the bottle to one-third with clean water. Add approximately the same volume of dry soil passed through a 6mm sieve and add a teaspoonful of common salt. Firmly close the lid of the bottle and shake until the soil and water are well mixed. Allow the bottle to stand on a flat surface for about half an hour. Shake the bottle again for two minutes and stand on level surface for a further 45 minutes until the water particles fall more slowly and as a result, it will get deposited on top of the larger size particles. Two or three layers will emerge, with the lowest layer containing fine gravel, the central layer containing the sand fraction. The depth of each layer is measured and hence percentages, of each fraction can be determined.

Other simple tests like adhesion test, washing tests etc could also be carried out at the site to understand the nature of soil and requirement of sand.

2.1.2. Breaking and Sieving of Soil

In order to obtain a uniform mix of the mineral components, water and stabilizer, lumps more than 200mm in diameter after excavation must be broken up. Grains with a homogeneous structure, such as gravel and stones, must be left intact, and those having a composite structure (clay binder) broken up so that at least 50 percent of the grains are less than 5mm in diameter. The soil must be dry as wet soil can only be handled by certain mechanized systems.

a. Grinding followed by screening

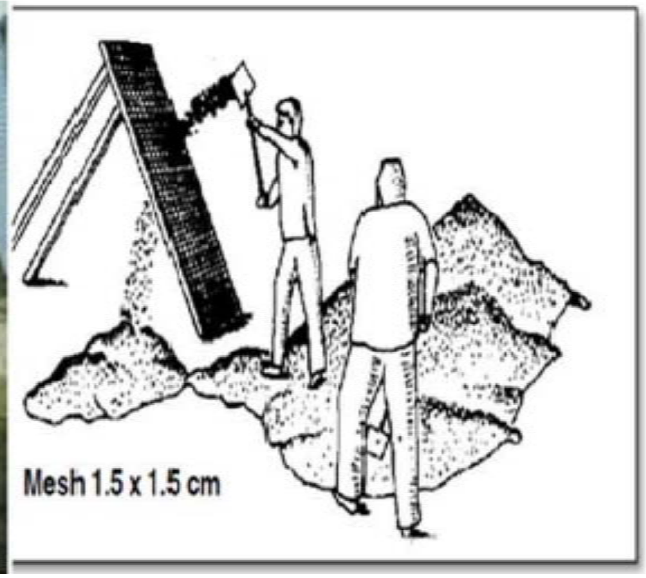
The material is pressed between two surfaces - a rather inefficient and tedious process in which bigger stones are broken up, however, only simple machinery is required. The broken up lumps of soil are then passed through a screen.

b. Pulverization of soil

The material is hit with great force so it disintegrates. The machinery required is complex but performs satisfactorily. At the delivery end, any large pieces left can be removed by means of screen.

c. Sieving

Soil contains various sizes of grain, from very fine dust up to pieces that are still too large for use in block production. The oversized material should be removed by sieving, either using a built-in sieve, as with the pendulum crusher, or as a separate operation. The simplest sieving device is a screen made from a wire mesh, nailed to a supporting wooden frame and inclined at approximately 45^{o} to the ground. The material is thrown against the screen, fine material passes through and the coarse, oversized material runs down the front. Alternatively, the screen can be suspended horizontally from a tree or over a pit. The latter method is only suitable in the case where most material can pass through easily otherwise too much coarse material is collected, and the screen becomes blocked and needs frequent emptying.

2.1.3. Proportioning

Before starting production, tests should be performed to establish the right proportion of soil, stabilizer and water for the production of good quality blocks. The proportions of these materials and water should then be used throughout the production process. To ensure uniformity in the compressed stabilized earth blocks produced, the weight or volume of each material used in the block making process should be measured at the same physical state for subsequent batches of blocks. The volume of soil or stabilizer should ideally be measured in dry or slightly damp conditions. After establishing the exact proportion required of each material, it is advisable to build a measuring device for each material. The dimensions of each measuring box should be such that their content, when full, is equivalent to the proportion which should be mixed with other materials measured in other gauge boxes. Alternatively, a simple gauge box may be used for all materials. In this case, the amount of material for the production of a given batch of blocks may be measured by filling and emptying the gauge box a number of times for each separate material. For example, a batch of blocks may require ten gauge boxes of soil for one gauge box of stabilizer. Water may be measured in a small tank or container. It is advisable to mix enough materials to allow the block-making machine to operate for approximately one hour. Thus, the volume of the mixed material will depend on the hourly output of the block making equipment.

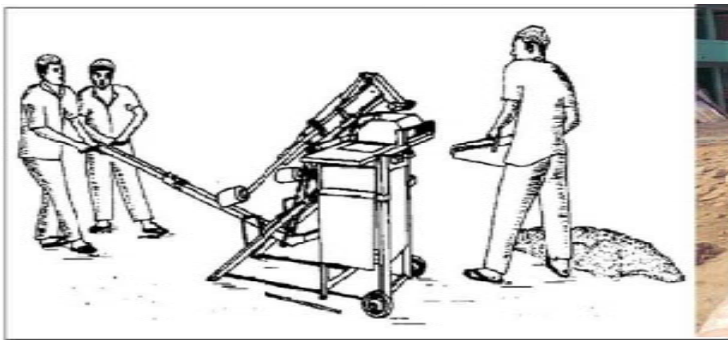
2.1.4. Mixing

In order to produce good quality blocks, it is very important that mixing be as thorough as possible. Dry materials should be mixed first until they are of uniform color, then water is added and mixing continued until a homogeneous mix is obtained. Mixing can be performed by hand on a hard surface, with spades, hoes, or shovels. It is much better to add a little water at a time, sprinkled over the top of the mix from a watering can with a rose spray on the nozzle. The wet mix should be turned over many times with a spade or other suitable tool. A little more water may then be added, and the whole mixture turned over again. This process should be repeated until all the water has been mixed in. A concrete mixer, even if available, will not be useful for mixing the wet soil, since the latter will tend to stick on the sides of the rotating drum. If machinery is to be used for mixing, it should have paddles or blades that move separately from the container. Hand-mixing methods are often more satisfactory, more efficient and cheaper than mechanical mixing, and are less likely to produce small balls of soil that are troublesome at the block moulding stage.

- Pour in order, soil, sand and stabilizer
- First Mix dry , 2 times
- Add water and mix wet, 2 times

2.1.5. Moulding of CSEB

To manufacture blocks of uniform size and density, special precautions must be taken to mould with the same amount of mix for each compaction by using a small wooden box as a measuring device. To facilitate development of the pressed blocks and to ensure good neat surfaces it is advisable to moisten the internal faces of the machine which can be applied with a rag, brush or spray. Aurum press 3000 is for moulding the CSEB




2.1.6. Curing of CSEB

To achieve maximum strength, compressed stabilized earth blocks need a period of damp curing, where they are kept moist. If the block is left exposed to hot dry weather conditions, the surface material will lose its moisture and the clay particles tend to surface cracks on the block faces. In practice, various methods are used to ensure proper curing. Such methods include the use of plastic bags, grass, leaves, etc. to prevent moisture from escaping. The required duration of curing stabilizer is used. **With cement stabilization, it is recommended to cure blocks for a minimum of three weeks.** The curing period for lime stabilization should be at least four weeks. Compressed stabilized earth blocks should be fully cured and dry before being used for construction.

Golden Rule

- The pile must remain covered 2 days with a plastic sheet
- Stacking the fresh block
- Cover immediately every row with a plastic sheet.
-


2.1.7. Quality Control

Compressed stabilized earth building blocks are usually larger in size than traditional burnt bricks. A typical block size is 240 x 140 x 90mm. The exact amount of stabilizer necessary must be established for any particular project. The fraction of cement usually varies between 5% to 8% by weight.

Golden rules

- To create a joyful atmosphere where everybody is conscious of the quality required and check the blocks.
- Check the production at every stage
- Check the quality of the compression with the pocket penetrometre, always for the first block of every mix.
- Check the height with the block height gauge, always for the first block of every mix.
- Follow the production daily. Record the output and dates...
- Check weekly or monthly, the production with the field block tester (after 28 days).

3. Production of CSEB (Compressed Stabilized Earthen Block)

Lay out and Sub Structure Construction

Construction of CSEB building is similar to any other building construction using the simple brick. It starts with lay out of the building on the ground followed by trench digging, ramming of earth, stone soling and PCC on which the foundation is laid out. As per the design drawing, the foundation is also made up of stabilized soil. In some cases it could be made up of stone masonry too. The foundation is laid as in case of load bearing brick in cement mortar. The Step foundation is constructed.

At DPC level, first tie beam is constructed where U-Block is used as formwork. 2-12mm dia bars with 6mm stirrups @250mm cc reinforcement is provided in the DPC level Tie Beam. Further a 1 feet buttress wall is projected at the mid of the span on either side. Further a vertical reinforcement is provided at the corner and on either side of the openings as per the provision of NBC 203. These features enhance the strength of building against earthquake or horizontal forces.

Super Structure Construction

This is characterized by construction of wall, positioning of door and windows, and construction of will and lintel bands. The vertical ties and the ring beams consist of reinforcement of 2-10mm diameter bars whereas the lintel consists of reinforcement of 2-12mm diameter bars owing to more flexure that it has to bear from the above wall. The bands, at corners and T-joints, consist of extra bars of 10mm extending 50cm along each adjacent wall for additional reinforcement. The stirrups of 8mm bars are arranged in all case at spacing of 25cm.

9. Door Installation

10. U-Block for Sill Band

11. Concreting of Sill Band

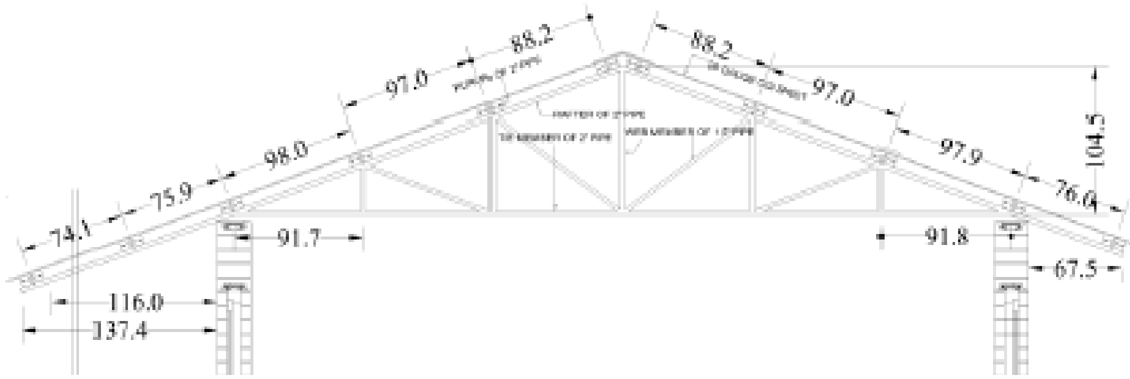
12. Window Installation

13. Reinforcement for Lintel

14. Full Model Structure

All courses should be bound by cement stabilized earth mortar 1 cement: 1 soil: 3 sand. It should be plastic and not too liquid. The soil should not have more than 20-25 % of clay. All joints, horizontally and vertically, are 5 mm thick. Note a cement sand mortar (i.e. 1: 4) will have a very low workability as the mortar thickness is only 5mm. **The blocks must be soaked before being laid and a well-laid block is impossible to remove with one hand because it sticks well to the cement sand mortar.** All the holes, with or without reinforcement, and all ring beams, are filled with plain cement concrete 1: 1.5: 3. The plasticity of the concrete for the holes is rather fluid, but not liquid. It should flow well in the holes without being a soup. It is essential to compress very well the concrete with a steel rod.

CGI Sheet Truss Roof
Lattice steel trusses are fabricated from **tubular steel sections** that are cut, mitered and welded. CGI sheet roof as we all know has advantages like maintenance free, leakage free, fire resistance etc. But it has many defects too. It is extremely hot during summer and scorching cold during winter. Hence false ceiling are provided to maintain indoor comfort level.



4. Earthquake Safety Features

Nepal faces a high frequency of seismic hazards. However, it can be well seen that even the basic norms for its prevention has not been implemented in the built structures. Through this project, the criteria that have to be taken into earthquake proof building are highlighted so as to create an awareness among the local people regarding their safety in the buildings.

The five horizontal ring beams are tied together by the vertical ties. Together the horizontal and vertical ties make a skeleton like network of reinforcement. The idea is that the metal reinforcements bring ductility (flexibility) to the building and the building is able to absorb a lot of energy before a major damage. In the event of an earth quake not collapse and if it has to collapse then it should give enough time to the people to leave thebuilding.

Following seven features are considered for the CSEB Project as the earthquake features:

Building Shape
The building is proposed as rectangular in shape which is the best shapes for earthquake resistant buildings due to regular shapes and perfectly symmetrical in two axes. In this case the centers of gravity and rigidity will be the same and therefore the building is safe

Ductility
Masonry components are most of the time brittle ones. Reinforcements are added to make a structure more ductile with these brittle materials. Ring beams at various levels, which are linked together with vertical ties, will reinforce the structure very well and make it ductile.

Rigidity Distribution
The centre of gravity of the plan lies on the centre of rigidity of the vertical masses. This would avoid torsion of the building. The vertical rigidity of the building is well distributed.

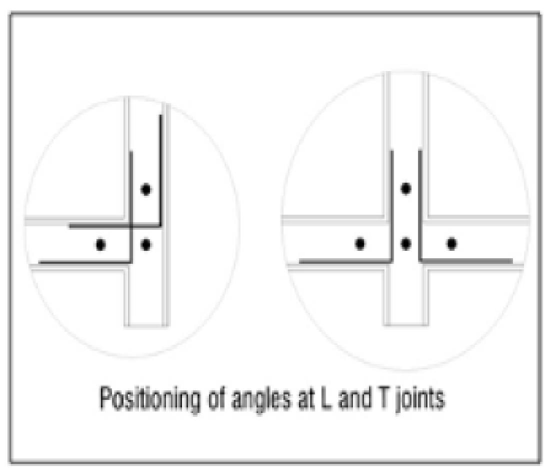
Simplicity
Simplicity in the ornamentation is the best approach. Large cantilevered projections, cladding materials, etc are dangerous during earthquakes. They are avoided.

Foundation
Certain types of foundations are more susceptible to damage than others. Isolated footing of columns can easily be subjected to differential settlement, particularly when they rest on soft soils. Mixed foundations in the same building are also not suitable. What works best in most of cases is trench foundation.

Openings
Doors and windows reduce the lateral resistance of walls to shear. Hence, they should preferably be small and rather centrally located. The specification mentioned in IS 4326: 1993 are followed.

Structural Integrity (Box Action)
Past earthquakes have shown that damage to masonry buildings is significantly reduced when building components are well connected and the building vibrates like a monolith box. There is a need to provide additional elements to tie the walls together and ensure acceptable seismic performance. Structural integrity of a building can be achieved by developing a box action by ensuring good connections between all building components like foundations, walls, floors, and roof.

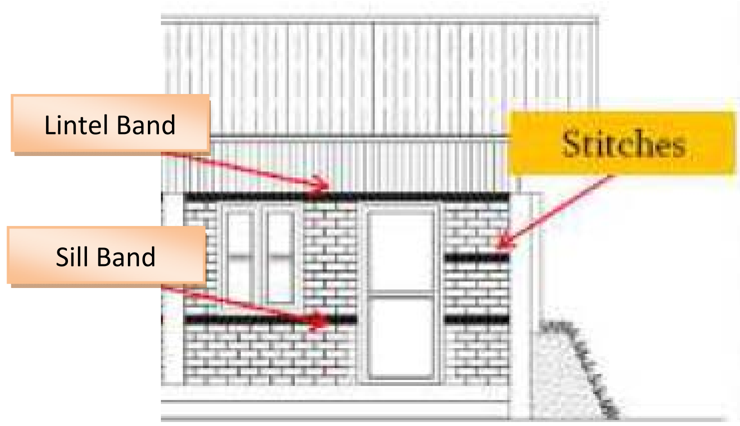
Connection betwee enn walls



Positioning of aangles at L and T joints

Key requirements for the structural integrity in a masonry building are:

- Stiff foundation
- Good connection between wall and foundation
- Good connection at wall corners
- Ring beam
- Vertical ties
- Small openings
- Good connection between wall and roof



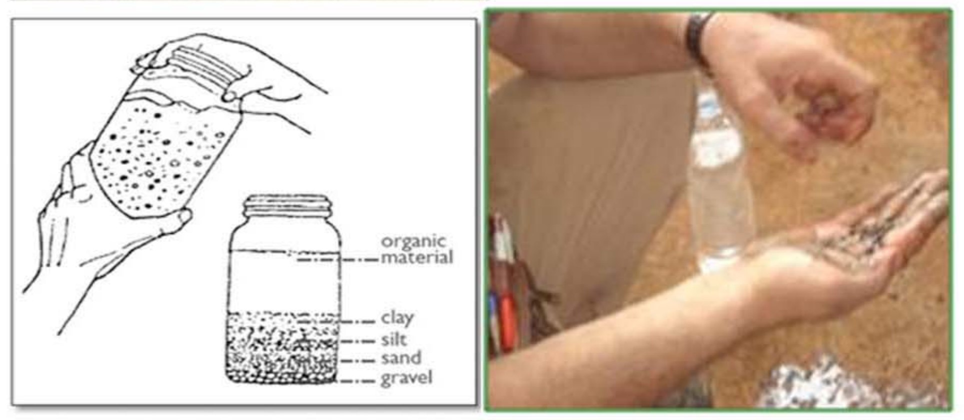
5. Conclusion

CSEB provides an alternative construction material for rural construction where most of the buildings are less that of 3 storied. It can replace brick and stone without compromising any strength. Further addition of earthquake resistant technology makes it earthquake resilient. The technology is green that does not use any energy and reduces dependency on forests. Further the technology could be learnt at local level while working without any sophisticated trainings. The construction can generate employment and local level and hence can make the local economy more vibrant.

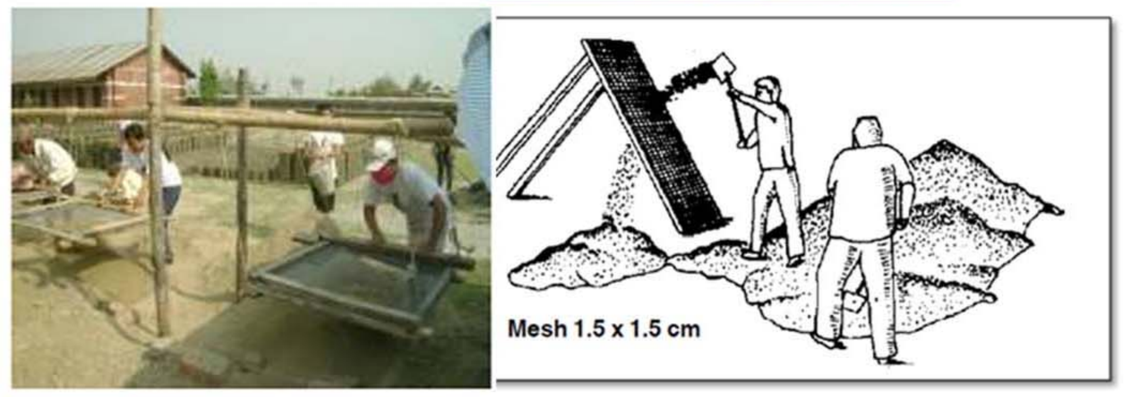
Annex 4: IEC Materials

CSEB Production

1. Soil Collection
Must be taken below
1'-6" from Ground
Level



2. Soil Test
- Touch Test
- Sedimentatuin
  Test



3. Breaking and Sieving
- Lumps more than 200mm Dia are broken down
- Soil must be sieved through 1..5cm X1.5cm mesh

4. Proportioning
- 5-7% of cement must be mixed in soil as stabilizer
- Measure all components directly in container
- Wheelbarrow: for Sand
- Bucket for Soil and Cement

5. Mixing
- Pour in order soil, sand, stabilizer
- First Mix Dry 2 times
- Add water and wet mix 2 times

6. Moulding
- Aurum press 3000 is used for moulding

7. Curing
- Must kept moist to achieve max.strength
- 3wks curing for cement stabilizer
- 4 wks curing for lime stabilizer
- use of polythene bags, grass, leaves etc

TOOLS USED FOR CSEB BLOCKS

Bucket

Shovel

Karni

CONSTRUCTION TECHNOLOGY

CSEB Construction

Cost is 10%less than

fired brick cost

i.e. Rs. 1600/sq.ft.

14. Full Model Structure

13. Reinforcement for Lintel

W A L L C O N S T R U C T I O N

12. Window Installation

11. Concreting of Sill Band

10. U-Block for Sill Band

P L I N T H B E A M C O N S T R U C T I O N

9. Door Installation

8.Completed Plinth Beam

7.Reinforcement in plinth beam

6. Laying of blocks

5. Vertical Reinforcement

S U B - S T R U C T U R E C O N S T R U C T I O N

1. Building Layout

2. Foundation Trench

3.Rammed Earth

4. Stone Soling

FOR MORE DETAIL CONTACT:

Center of Resilient Development (CoRD)
Basundhara, Kathmandu.
PO Box: 1681, Kathmandu, Nepal
Phone No: +977 1 4387023
Email: info@cordvia.org
Website: www.corvia.org

Compresses Stabilized Earthen Block (CSEB) an alternative for reconstruction

Introduction

Nepal Earthquake, April 2015 has taken away breathe of Nepalese people in despair and houses were mingled within the ground. Economical and Green reconstruction is the need aftermath of earthquake. CSEB is one of the technologies which uses local material/ knowledge and provide aesthetic look.

Figure: CSEB Blocks

Center of Resilient Development (CoRD) has been advocating on this technology and had built 16 school buildings made up of CSEB before April 2015 Nepal Earthquake. Among them four school buildings has been built at Dolakha. Those school buildings at Dolakha have withstood the stroke of April 2015. At present, CoRD in collaboration with UNDP established Technological Demonstration Center (TDC) at Gorkha to disseminate information on CSEB.

CSEB a green approach

CSEB does not use any energy therefore; it is green and environment friendly. It is climate responsive, environment friendly, earthquake safe and cost effective too. CSEB has many advantages over fired bricks as portrayed in table 1.

At the same time, being labor intensive technique, it offers the possibility of creating employment for thousands of masons and skilled labor. Therefore, it involves community participation, create employment and empowerment.

Pollution emission(Kg of CO_2/m2)	7.9 times less than country fired bricks			
Energy consumption (MJ)	15.1 times less than country fired bricks			
Ecological comparison of building materials				
Product and thickness	No of Units (per m2)	Energy consumption (NJ per m2)	CO2emission (Kg per m2)	Dry compressive strength (Kg/cm2)
CSEB-24 cm	40	110	16	40-60
Wire Cut Bricks-22 cm	87	539	39	75-100
Country Fired bricks-22cm	112	1657	126	30-100
Concrete blocks-20 cm	20	235	26	75-100

Table 1: Benefits of CSEB over fired Bricks

CSEB production

Materials

For CSEB, cement stabilization with 5% to 7% cement can be done if the soil at site constitutes of

Gravel: 15%, Sand: 50%, Silt: 15% and clay: 20%

Otherwise, cement and gravel has to be mixed accordingly as per soil physical property.

Tools Used

Bucket

Aurum 3000

Shovel

Karni

Mug

Testing at local level

- Fill the bottle to one-third with clean water. Add approximately the same volume of dry soil passed through a 6mm sieve and add a teaspoonful of common salt.
-Firmly close the lid of the bottle and shake until the soil and water are well mixed. Allow the bottle to stand on a flat surface for about half an hour.
-Shake the bottle again for two minutes and stand on level surface for a further 45 minutes until the water starts to clear.
-Two or three layers will emerge, with the lowest layer containing fine gravel, the central layer containing the sand fraction and the top layer containing silt and clay.
- Depth of layer will be measured and percentage of the constituents is calculated

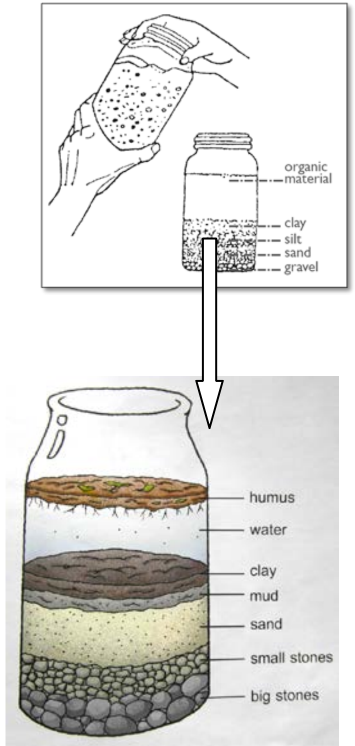


Figure: Soil test at local level

CSEB Making Process

- Thoroughly mix 5% to 7% of cement, sand and soil
- First mix 2 times in dry condition then another 2 times in wet condition

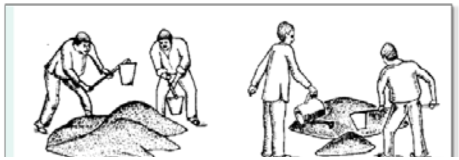


Figure: Mixing of materials

- Place the mixture into the mould and compressed it with the machine. Internal surface of the machine must be moist with a mould releasing agent
- CSEB produced should be carried to the site for storing and curing

Figure: Moulding, storing of CSEB

- CSEB must be cured with the help of plastic bags or moist jute for 3 weeks

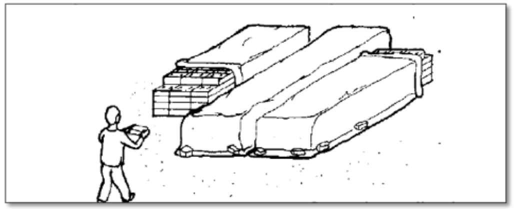


Figure: Curing of CSEB

CSEB Construction Technology

- Layout of the building on the ground
- Dig foundation, rammed and leveled
- Stone soling must be done with PCC on it for flat surface

- Vertical Reinforcement must be placed at corner and in every less than 1.5m in wall section
- CSEB blocks must be laid up to plinth level
- U- block must be placed at plinth level for plinth beam
- Reinforcement must be placed in the block and must be finished with PCC on its top

- Door must be installed
- CSEB must be laid on its top up to sill level and sill band must be constructed with U-block and reinforcement

- Window installation must be carried out
- Then lintel band must be constructed

- Roofing must be carried out with wooden truss and CGI Sheets on its top

Figure: Completed Structure of CSEB

CSEB Construction Cost

- Civil work of CSEB is economical than fired bricks
- It is 10% cheaper than fired brick
- Civil work of CSEB cost 1600 per square feet

For more detail Contact:

Center of Resilient Development (CoRD)

Basundhara, Kathmandu.

PO Box: 1681, Kathmandu, Nepal

Phone No: +977 1 4387023

Email: info@cordvia.org

'Awas' Construction Technology for Earthquake Affected Nepal

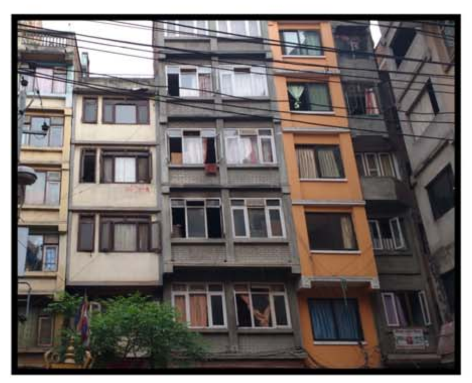
Want to build a disaster resistant house?

Material is not at fault for damage or collapse.

If bricks, stone, concrete blocks or cement are not used properly then the building gets damaged or can collapse.

So for new construction use any material depending on the location and the affordability. But use them as per **basic rules of construction** with **earthquake resistant features.**

Choose from the following three building systems



More than 3 story- Column-beam frame system

Up to 3 story - Load bearing masonry with concrete bands and vertical rods

Away from road- Load bearing- stone in mud with timber or GI wires

GI Wires Containment Technology

This is a technology with Earthquake Resisting Features of WWM and GI wires useful for up to two and a half storey building without any cement and steel bars.

This is a simple technology to make traditional construction of random rubble masonry in mud mortar earthquake resistant. It requires adherence to the **basic principles of good construction**. The **earthquake resisting features** are made GI containment wires anchored on the inside and outside wall faces along with Weld Wire Mesh band.

GI Wire Containment technology can really bring safety

Two models made on a table with wheels were given 14 powerful shocks by 1,500 kg pendulum.

First model of 1 and half story suffered much damage because of poor masonry and inadequate reinforcement

Second model of 2 and half story with better masonry and more reinforcement suffered very little damage.

How to prevent damage in new construction.

To prevent two faces from separating place stone to interlock with each other and place enough Through - Stones

To prevent vertical cracking install horizontal bands at plinth, sill, lintel, floor and roof level .

To prevent diagonal cracks encase the opening with reinforcement.

To prevent masonry gable wall collapse make the gable with timber or GI sheets .

To make the masonry walls ductile, provide vertical reinforcement in walls.

Design by NCPDP with financial support from UNDP- Nepal

National Centre For People's - Action In Disaster Preparedness. (NCPDP) INDIA Email : mitigation@ncpdpindia.org, Website : ncpdpindia.org

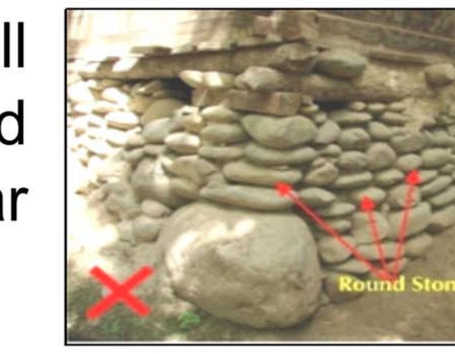
NCPDP-CEDAP

Local support: CoRD, Nepal

United Nations Development Programme, UNDP-Nepal

Basic rules of random rubble masonry

Never use round stones for masonry. Wall made with them is unstable. Round boulders must be broken to get angular faces for use in wall masonry.



Use angular stones that are often found on the mountain side and in gullies.

Thickness of the wall shall be not less than 350mm (15") and not more than 450mm (18") and all vertical and horizontal joints must be broken

Place lenth of each stone in to the thickness of wall to ensure interlocking of inside and outside faces of wall.

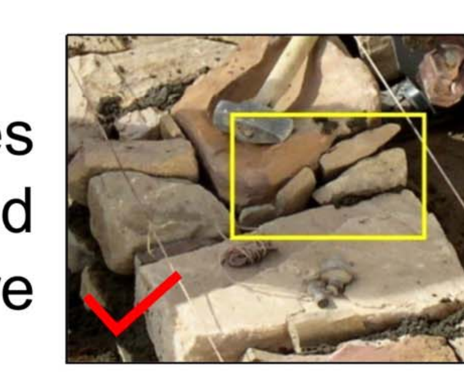
Provide "through-stone" one in every 0.7 sq.m. and arrange stones in zig-zag pattern in the wall breaking all vertical and horizontal joints in masonry

Place stones longer than the thickness of wall in the corner for strong wall to wall joint

Construct all walls at the same time. If not possible then leave the wall end in stepped manner

Place each stone flat on its broad face. Each stone must be in contact with the stone under it, not with mud mortar.

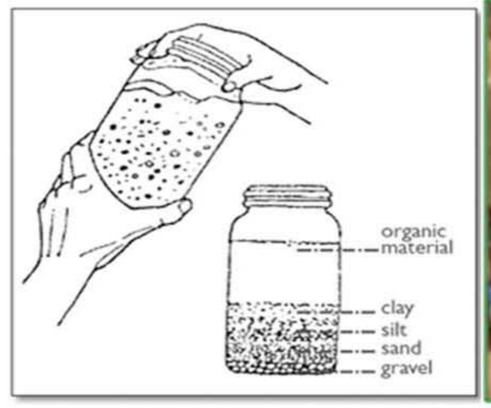
Use stone chips to fill gaps between stones instead of mortar. Never fill with round stones. The height of course shall not more than 600mm



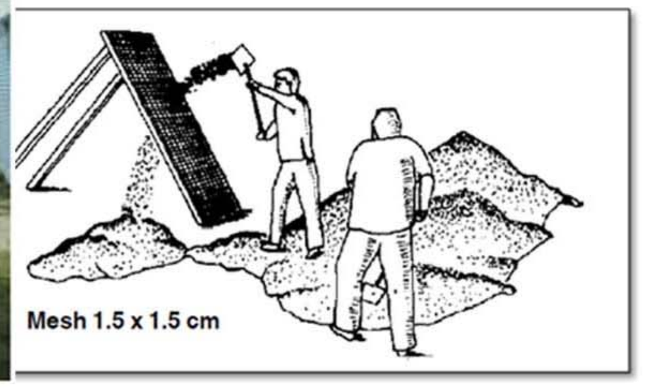
Never build corners first with toothing and then fill up the gaps between the corners. Construct corners and walls together.

CSEB Production

1. Soil Collection
Must be taken below 1'-6" from Ground Level

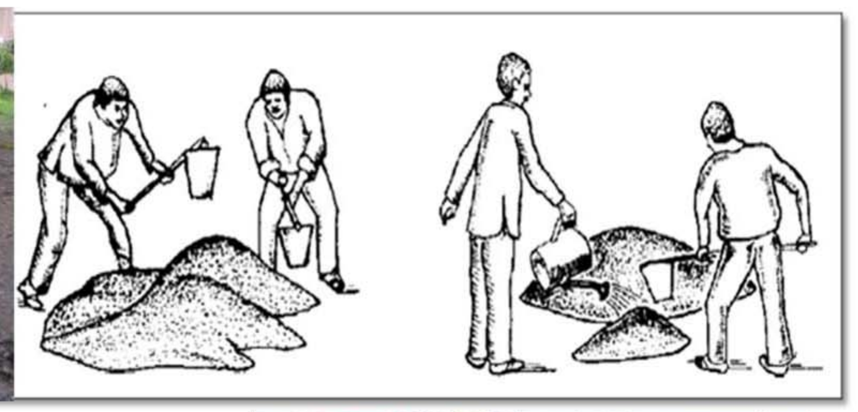


2. Soil Test
- Touch Test
- Sedimentatuin Test

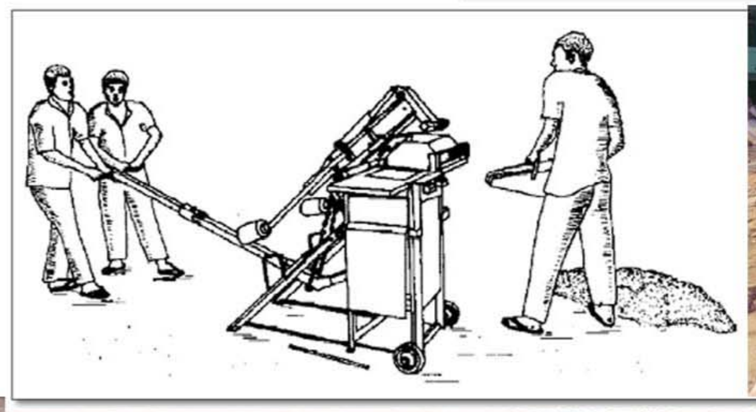


3. Breaking and Sieving
- Lumps more than 200mm Dia are broken down
- Soil must be sieved through 1..5cm X1.5cm mesh

4. Proportioning
- 5-7% of cement must be mixed in soil as stabilizer
- Measure all components directly in container
- Wheelbarrow: for Sand
- Bucket for Soil and Cement



5. Mixing
- Pour in order soil, sand, stabilizer
- First Mix Dry 2 times
- Add water and wet mix 2 times



6. Moulding
- Aurum press 3000 is used for moulding

7. Curing
- Must kept moist to achieve max.strength
- 3wks curing for cement stabilizer
- 4 wks curing for lime stabilizer
- use of polythene bags, grass, leaves etc

TOOLS USED FOR CSEB BLOCKS


Bucket


Shovel


Karni

CONSTRUCTION TECHNOLOGY

CSEB Construction Cost is 10%less than fired brick cost i.e. Rs. 1600/sq.ft.


14. Full Model Structure


13. Reinforcement for Lintel

W A L L C O N S T R U C T I O N


12. Window Installation


11. Concreting of Sill Band


10. U-Block for Sill Band

P L I N T H B E A M C O N S T R U C T I O N


9. Door Installation


8.Completed Plinth Beam


7.Reinforcement in plinth beam


6. Laying of blocks


5. Vertical Reinforcement

S U B - S T R U C T U R E C O N S T R U C T I O N


1. Building Layout


2. Foundation Trench


3.Rammed Earth


4. Stone Soling

FOR MORE DETAIL CONTACT:

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Email: info@cordvia.org
Website: www.corvia.org

Compresses Stabilized Earthen Block (CSEB) an alternative for reconstruction

Introduction

Nepal Earthquake, April 2015 has taken away breathe of Nepalese people in despair and houses were mingled within the ground. Economical and Green reconstruction is the need aftermath of earthquake. CSEB is one of the technologies which uses local material/ knowledge and provide aesthetic look.

Figure: CSEB Blocks

Center of Resilient Development (CoRD) has been advocating on this technology and had built 16 school buildings made up of CSEB before April 2015 Nepal Earthquake. Among them four school buildings has been built at Dolakha. Those school buildings at Dolakha have withstood the stroke of April 2015. At present, CoRD in collaboration with UNDP established Technological Demonstration Center (TDC) at Gorkha to disseminate information on CSEB.

CSEB a green approach

CSEB does not use any energy therefore; it is green and environment friendly. It is climate responsive, environment friendly, earthquake safe and cost effective too. CSEB has many advantages over fired bricks as portrayed in table 1.

At the same time, being labor intensive technique, it offers the possibility of creating employment for thousands of masons and skilled labor. Therefore, it involves community participation, create employment and empowerment.

Pollution emission(Kg of CO2/m2)	7.9 times less than country fired bricks			
Energy consumption (MJ)	15.1 times less than country fired bricks			
Ecological comparison of building materials				
Product and thickness	No of Units (per m2)	Energy consumption (NJ per m2)	CO2emission (Kg per m2)	Dry compressive strength (Kg/cm2)
CSEB-24 cm	40	110	16	40-60
Wire Cut Bricks-22 cm	87	539	39	75-100
Country Fired bricks-22cm	112	1657	126	30-100
Concrete blocks-20 cm	20	235	26	75-100

Table 1: Benefits of CSEB over fired Bricks

CSEB production

Materials

For CSEB, cement stabilization with 5% to 7% cement can be done if the soil at site constitutes of

Gravel: 15%, Sand: 50%, Silt: 15% and clay: 20%

Otherwise, cement and gravel has to be mixed accordingly as per soil physical property.

Tools Used

Bucket

Aurum 3000

Shovel

Karni

Mug

Testing at local level

- Fill the bottle to one-third with clean water. Add approximately the same volume of dry soil passed through a 6mm sieve and add a teaspoonful of common salt.

-Firmly close the lid of the bottle and shake until the soil and water are well mixed. Allow the bottle to stand on a flat surface for about half an hour.

-Shake the bottle again for two minutes and stand on level surface for a further 45 minutes until the water starts to clear.

-Two or three layers will emerge, with the lowest layer containing fine gravel, the central layer containing the sand fraction and the top layer containing silt and clay.

- Depth of layer will be measured and percentage of the constituents is calculated

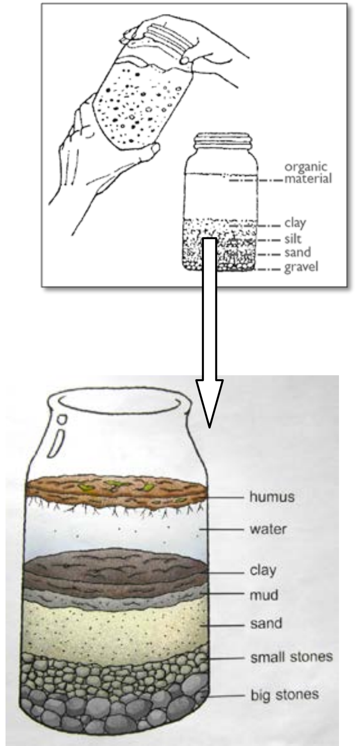

Figure: Soil test at local level

CSEB Making Process

- Thoroughly mix 5% to 7% of cement, sand and soil
- First mix 2 times in dry condition then another 2 times in wet condition

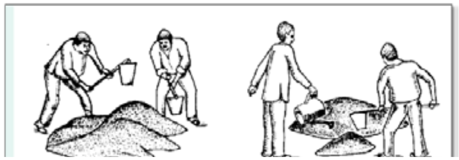

Figure: Mixing of materials

- Place the mixture into the mould and compressed it with the machine. Internal surface of the machine must be moist with a mould releasing agent
- CSEB produced should be carried to the site for storing and curing

Figure: Moulding, storing of CSEB

- CSEB must be cured with the help of plastic bags or moist jute for 3 weeks

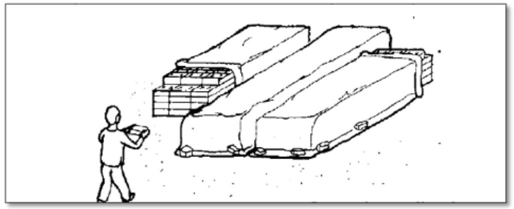

Figure: Curing of CSEB

CSEB Construction Technology

- Layout of the building on the ground
- Dig foundation, rammed and leveled
- Stone soling must be done with PCC on it for flat surface

- Vertical Reinforcement must be placed at corner and in every less than 1.5m in wall section
- CSEB blocks must be laid up to plinth level
- U- block must be placed at plinth level for plinth beam
- Reinforcement must be placed in the block and must be finished with PCC on its top

- Door must be installed
- CSEB must be laid on its top up to sill level and sill band must be constructed with U-block and reinforcement

- Window installation must be carried out
- Then lintel band must be constructed

- Roofing must be carried out with wooden truss and CGI Sheets on its top

Figure: Completed Structure of CSEB

CSEB Construction Cost

- Civil work of CSEB is economical than fired bricks
- It is 10% cheaper than fired brick
- Civil work of CSEB cost 1600 per square feet

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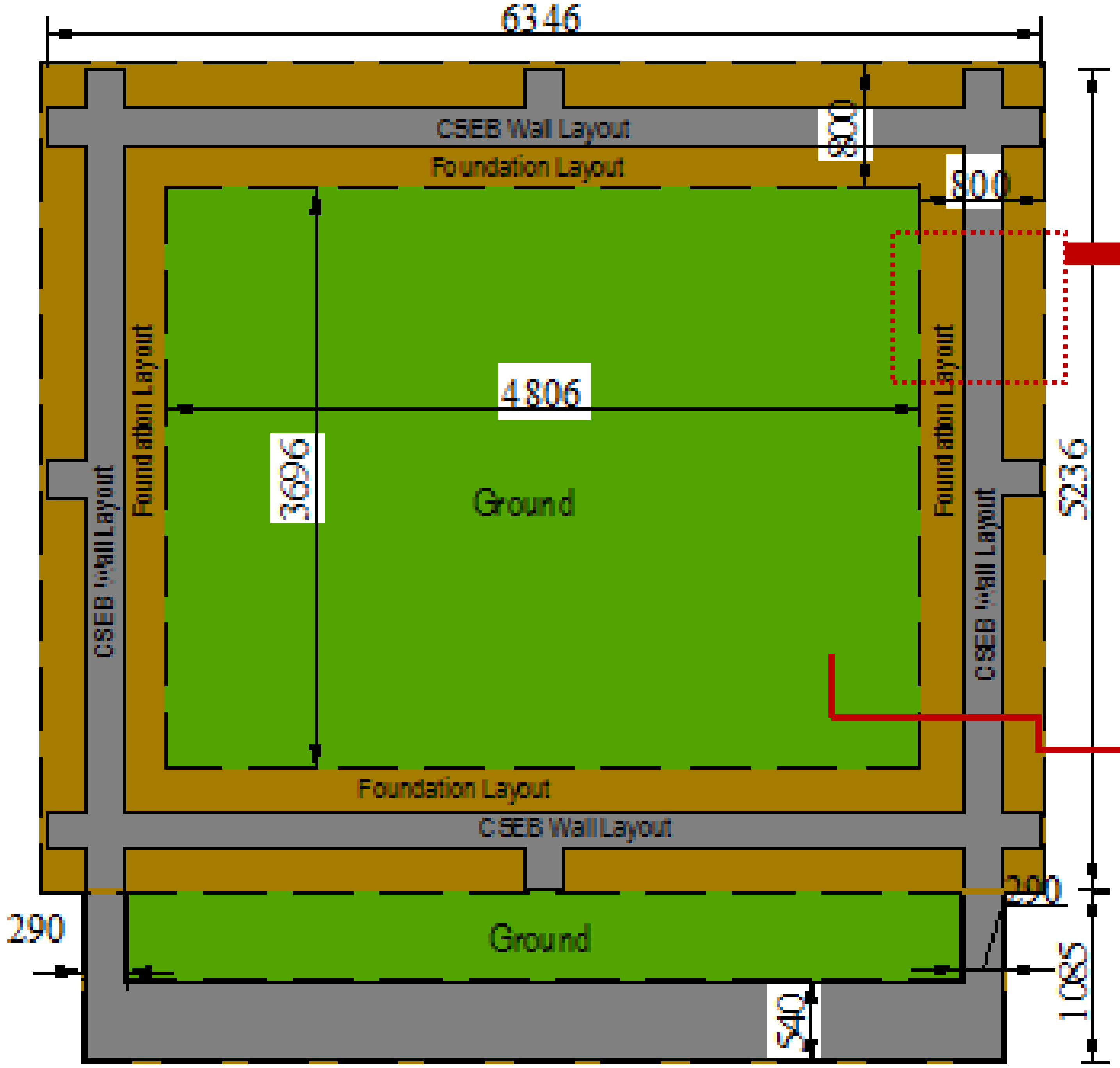
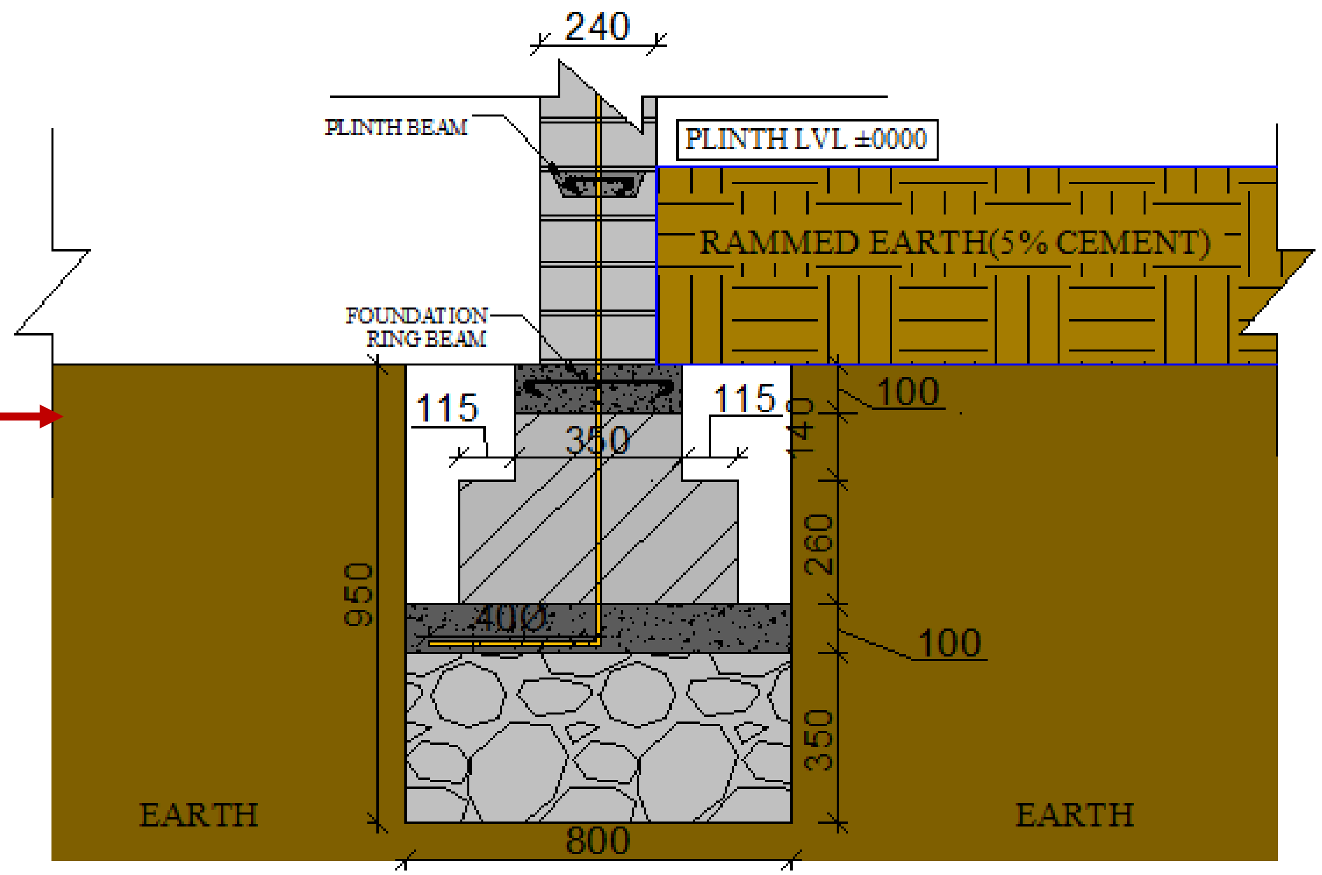
FOUNDATION LAYOUT

(जगको लेआउट)



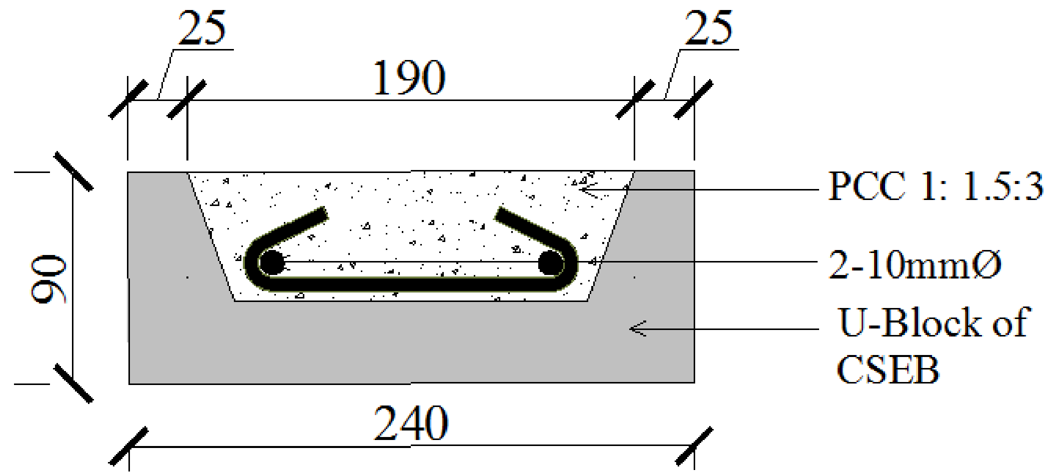
ट्रेन्च प्लान



जगमा गारोको भाग विस्तृतीकरण गरिएको

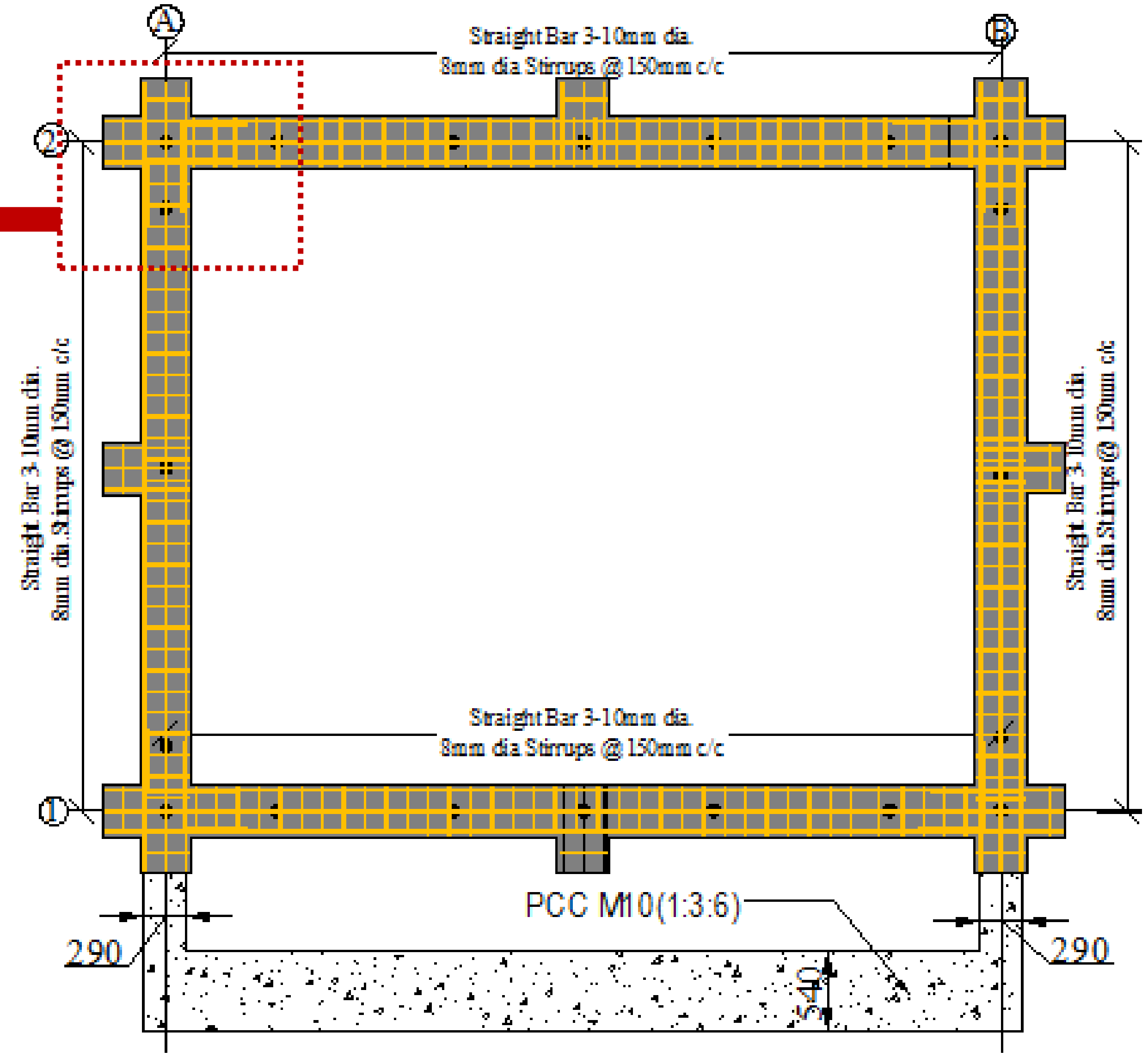
FOUNDATION RING BEAM

(जगमा रिङ्गको पोष्ठ देखाइएको)



रिङ्ग विमको फाउण्डेसन सेक्सन

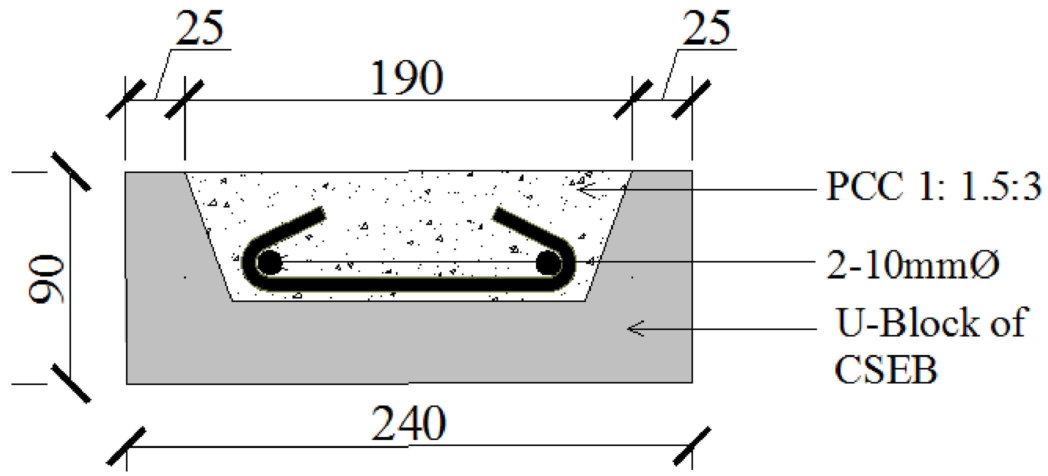
फउण्डेसन रिङ्ग विम निर्माण गर्ने प्रविधी



फाउण्डेसन रिङ्ग विम फलामे डण्डीहरुको डिटेल

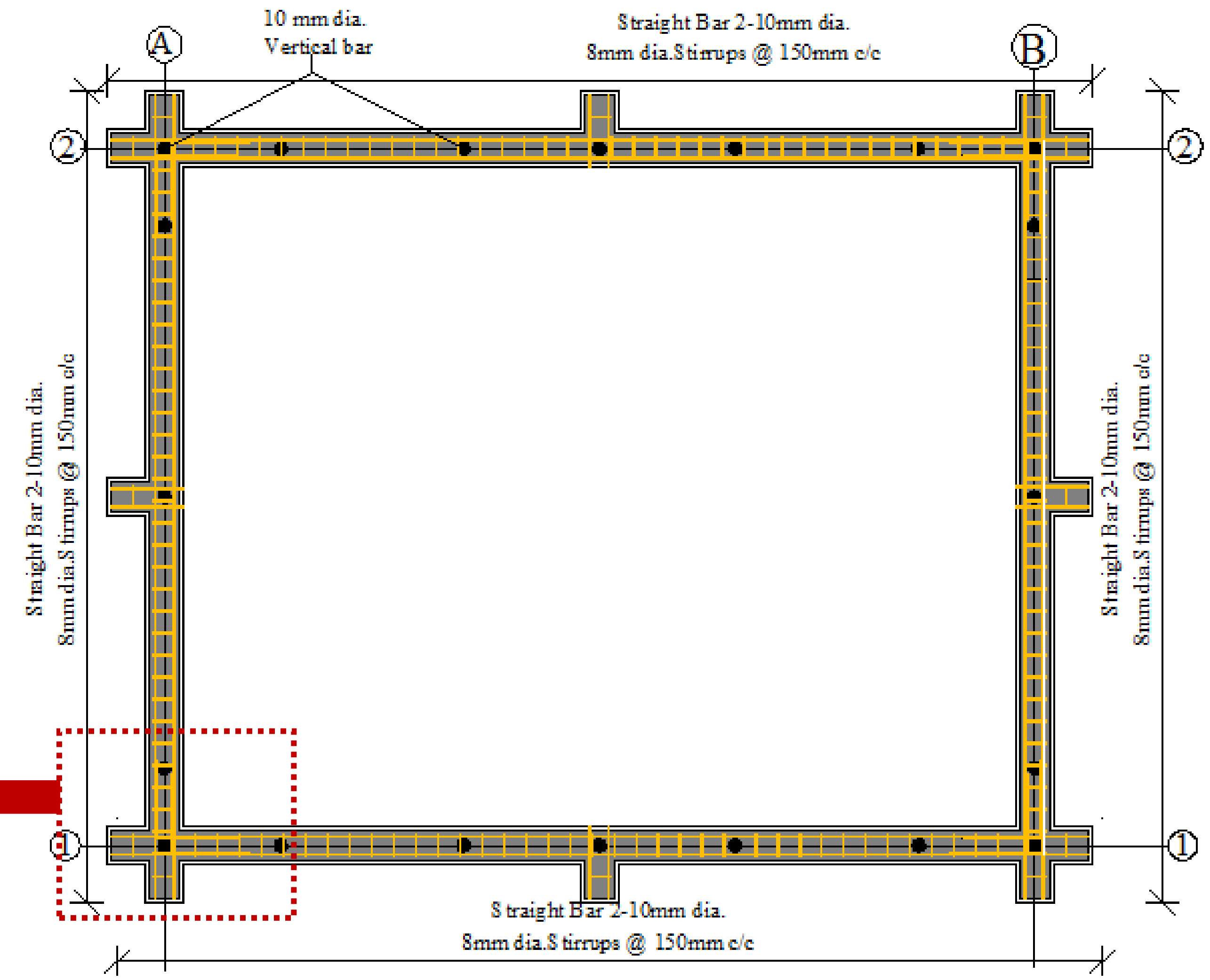
PLINTH BAND

(भुई माथीको प्लिन्थ वन्धन गरि देखाइएको)



भुई माथीको वन्धन सेक्सन

भुई माथीको वन्धन निर्माण विधी

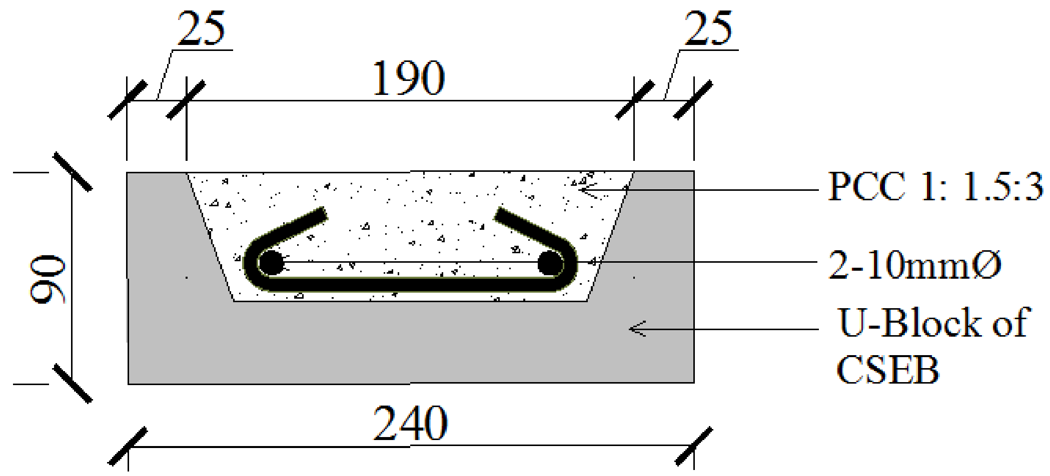


भुई माथी वन्धनको फलामे डण्डीहरुको डिटेल

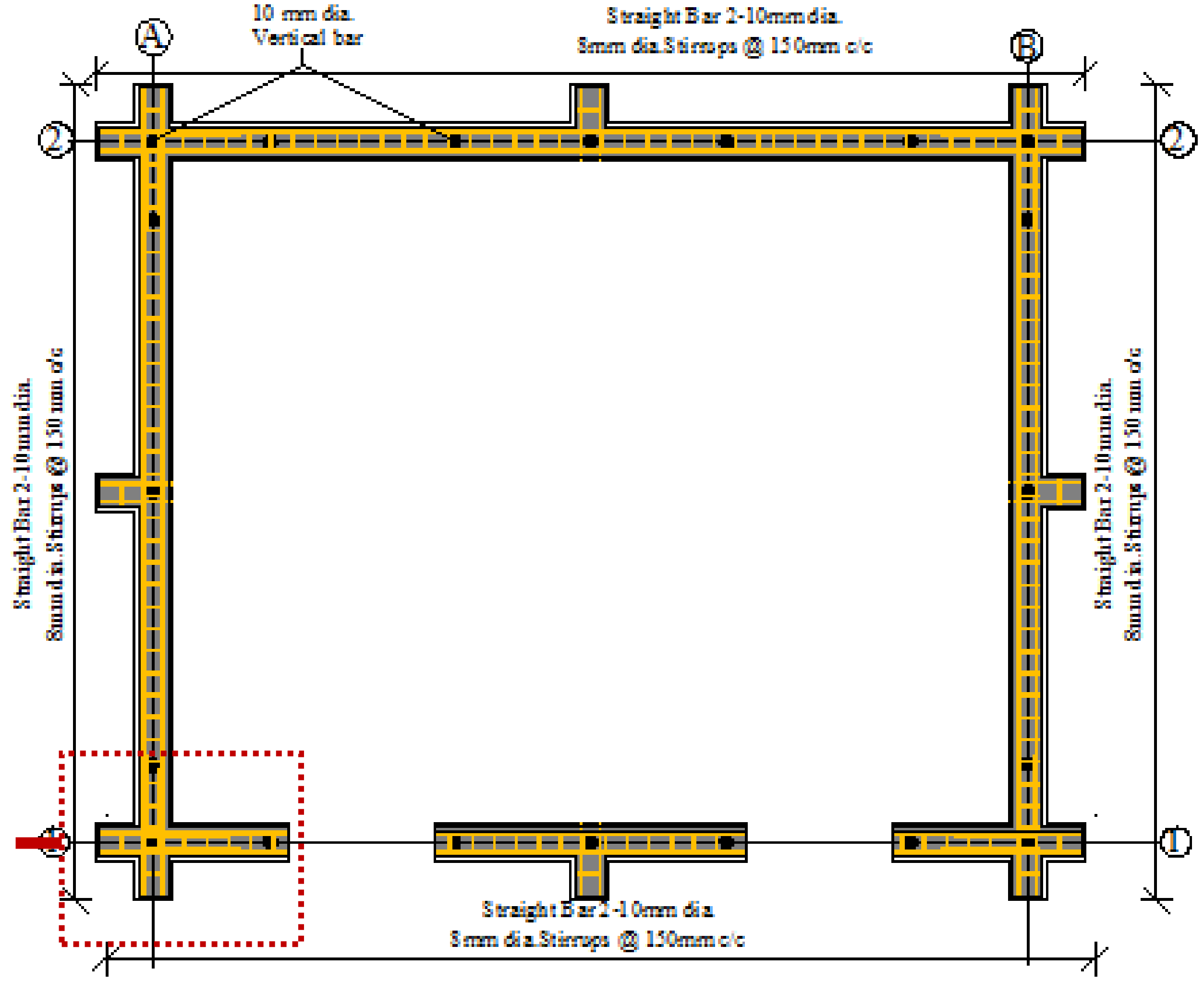
SILL BAND

(झ्याल तल,सिल वन्धन गरि देखाइएको)

झ्याल तल,सिल वन्धनको निर्माण विधी



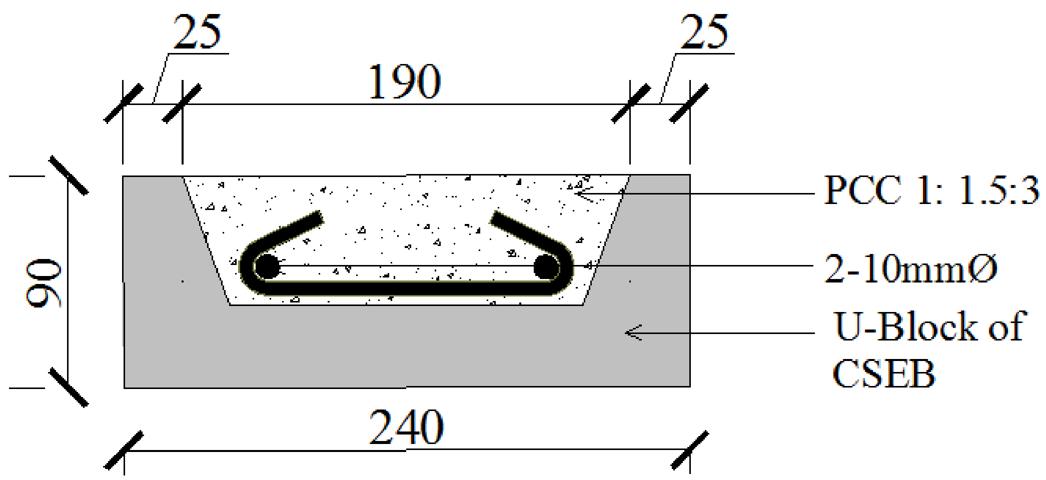
झ्याल तल सिल वन्धनको सेक्सन



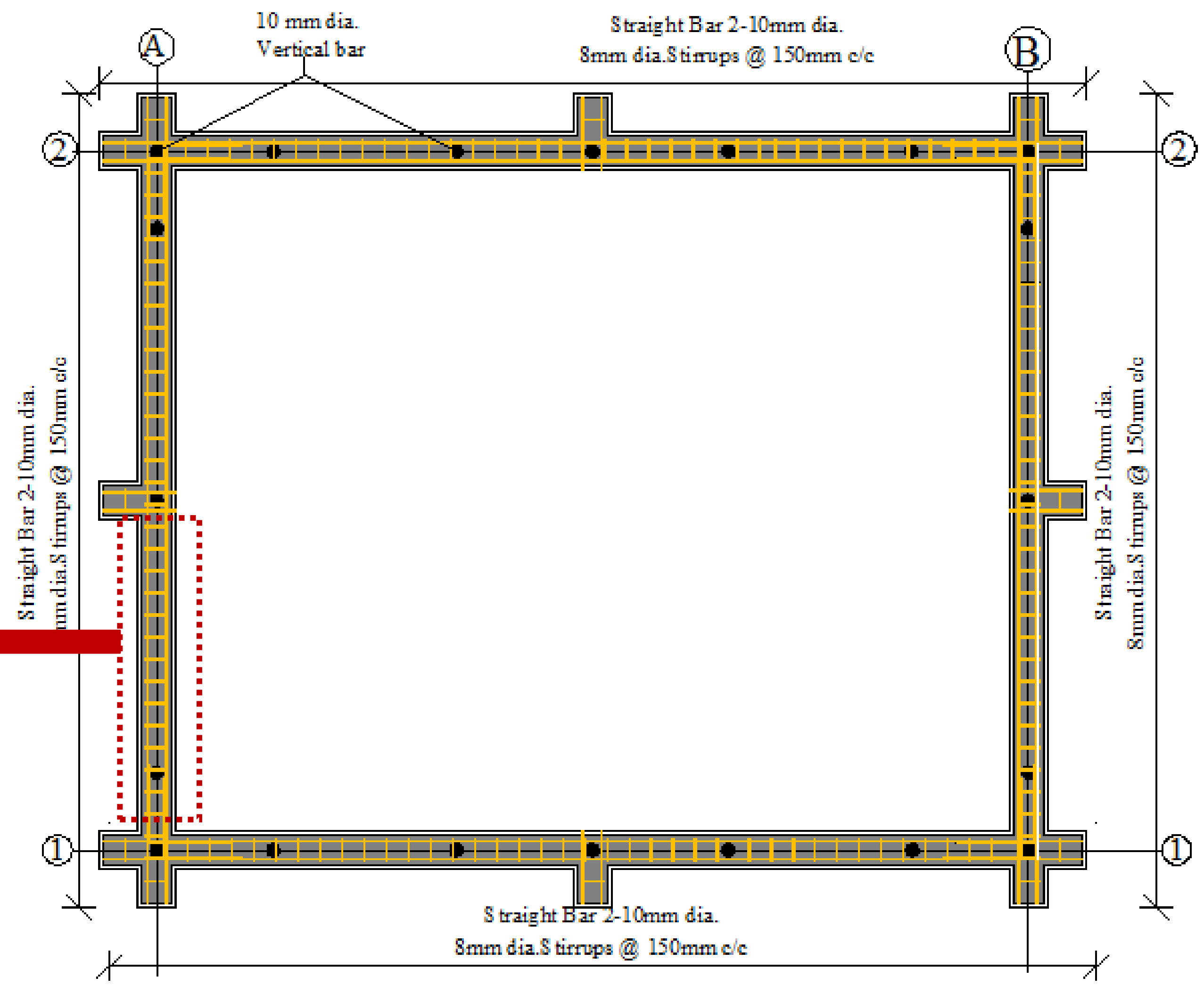
झ्याल तल,सिल वन्धनको फलामे डण्डीको डिटेल

LINTEL BAND

(झ्याल माथीको लिन्टल वन्धन देखाइएको)



झ्याल माथी लिन्टल वन्धनको फलामे डण्डीको डिटेल

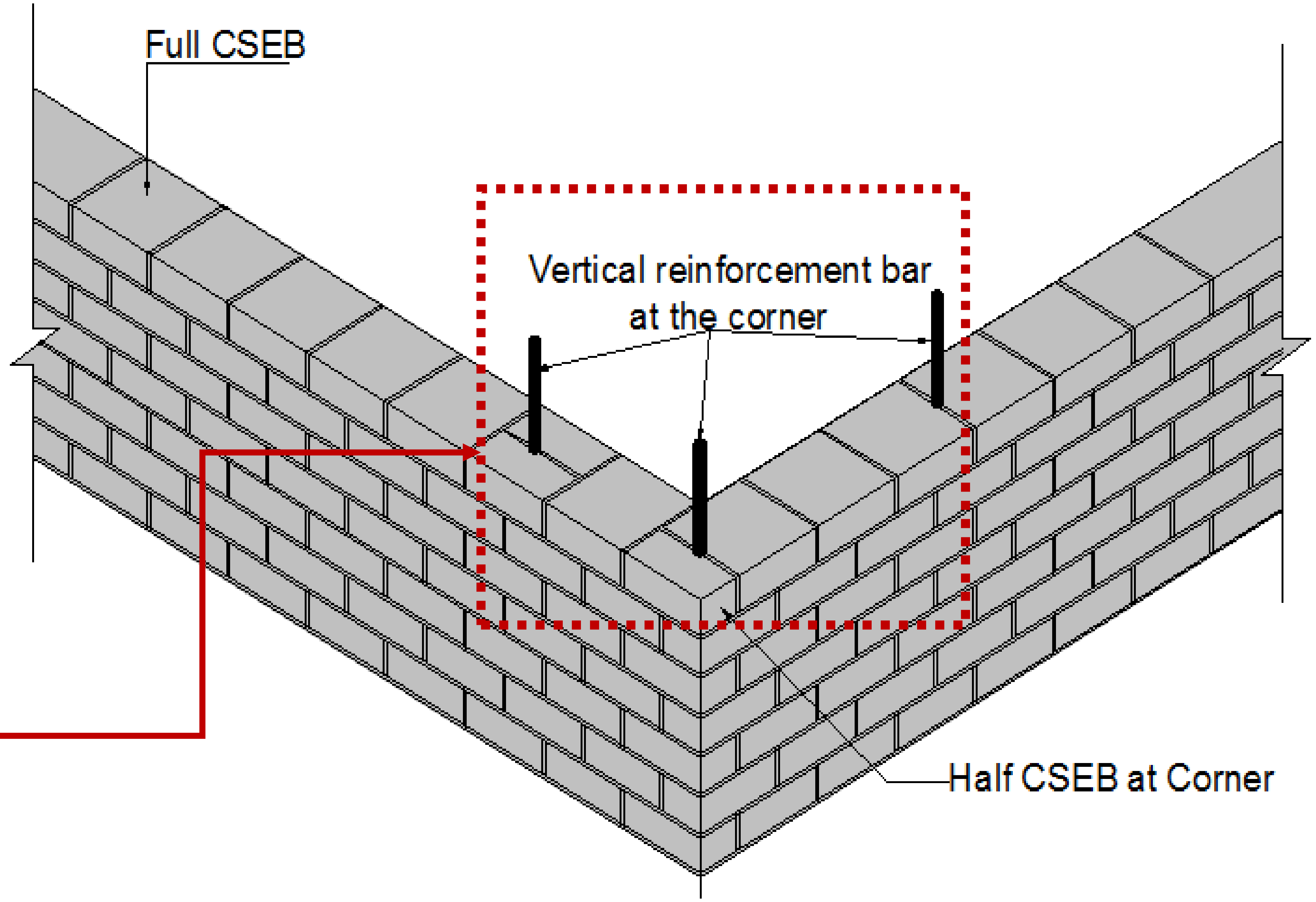


भ्याल माथीको लिन्टल वन्धनको निर्माण विधी

भ्याल माथीको लिन्टल वन्धनको फलामे डण्डीको प्लान

CSEB LAYING

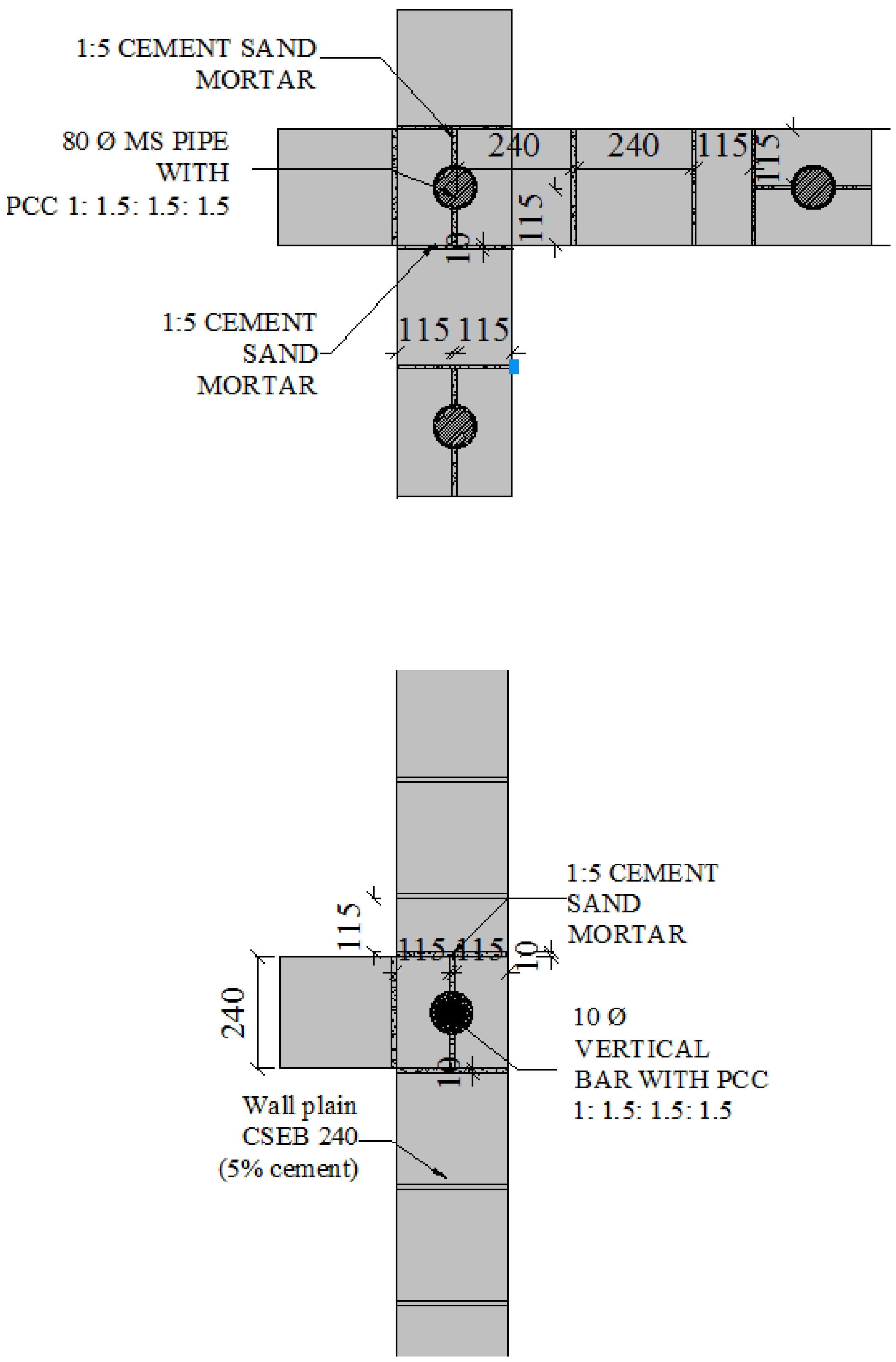
(सि.एस.ई.बि.वलक द्वारा निर्माण गरि देखाइएको)



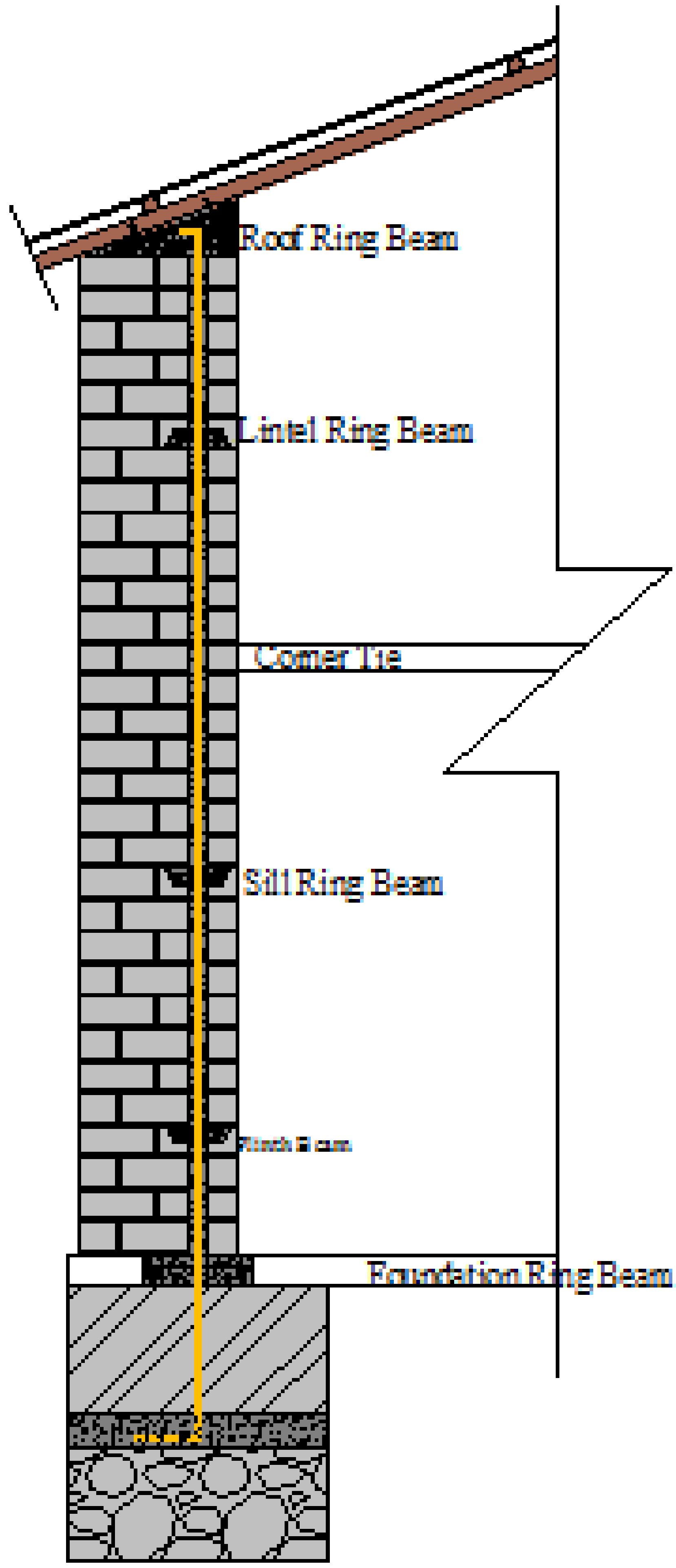
भवनमा कुनाका फलामे डण्डीको भाग राख्ने तरिका

VERTICAL REINFORCEMENT

(ठाडो भागमा फलामे डण्डीको भाग देखाइएको)



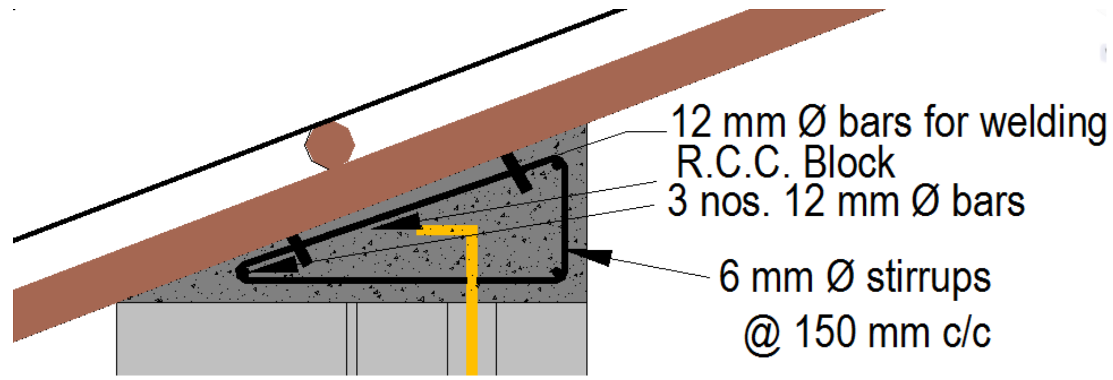
प्लानमा सि.एस.इ.वि को भागमा फलामे डण्डी देखाइएको



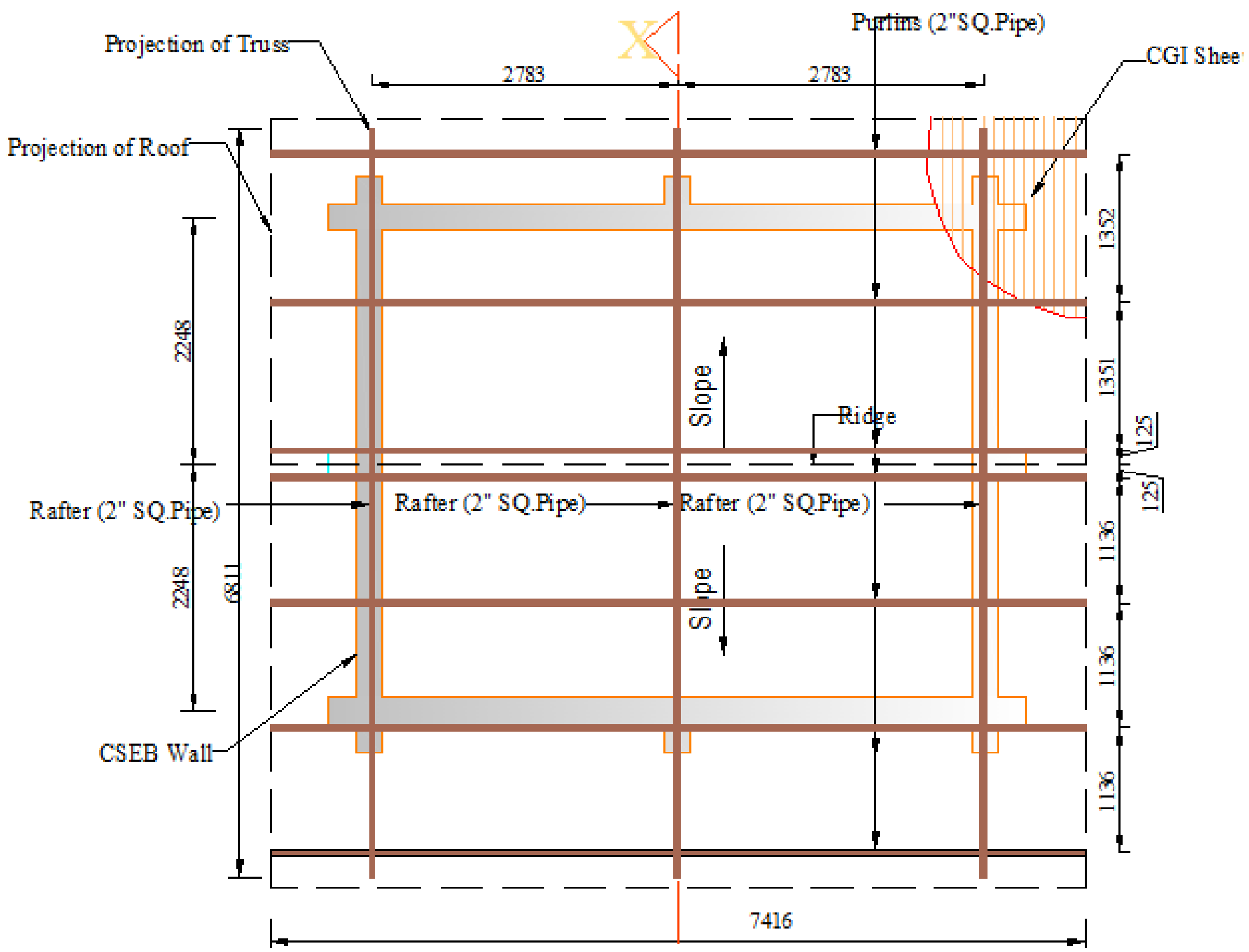
ठाडो फलामे डण्डीको भाग देखाइएको

ROOFING DETAIL

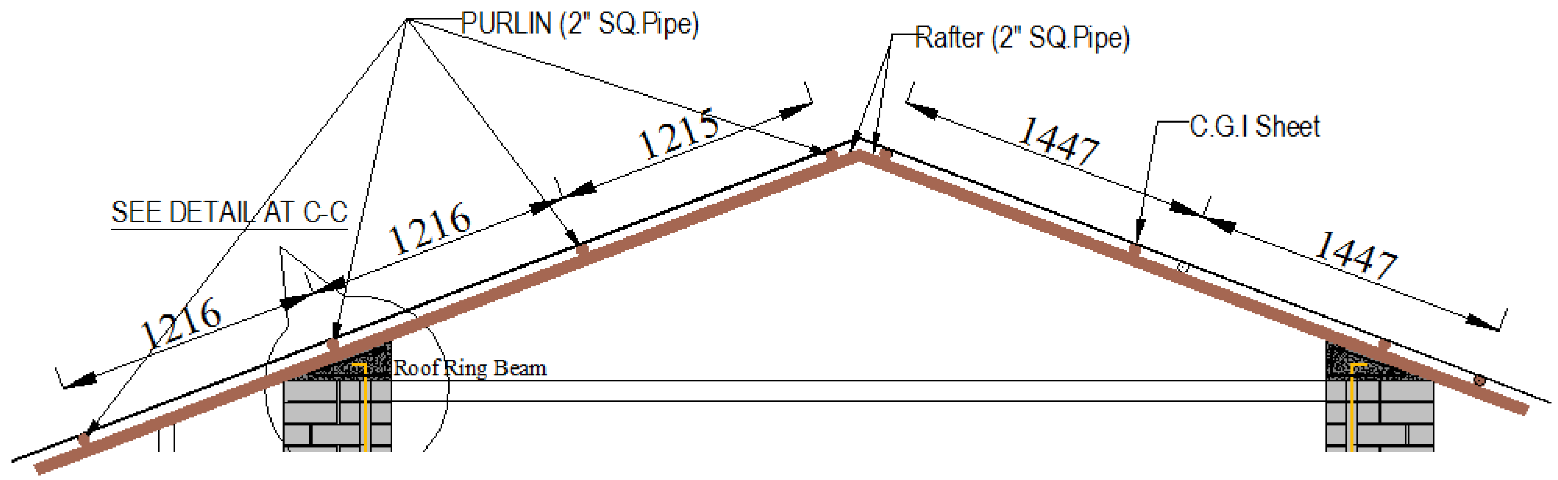
छानाको बिस्तृतीकरण गरिएको



DETAIL AT C-C



प्लानमा छानाको बिस्त्रृतीकरण



छानाको सेक्सन विस्तृतीकरण गरिएको