Lightweight Hybrid Multi-Storey Buildings

EXMO 2023

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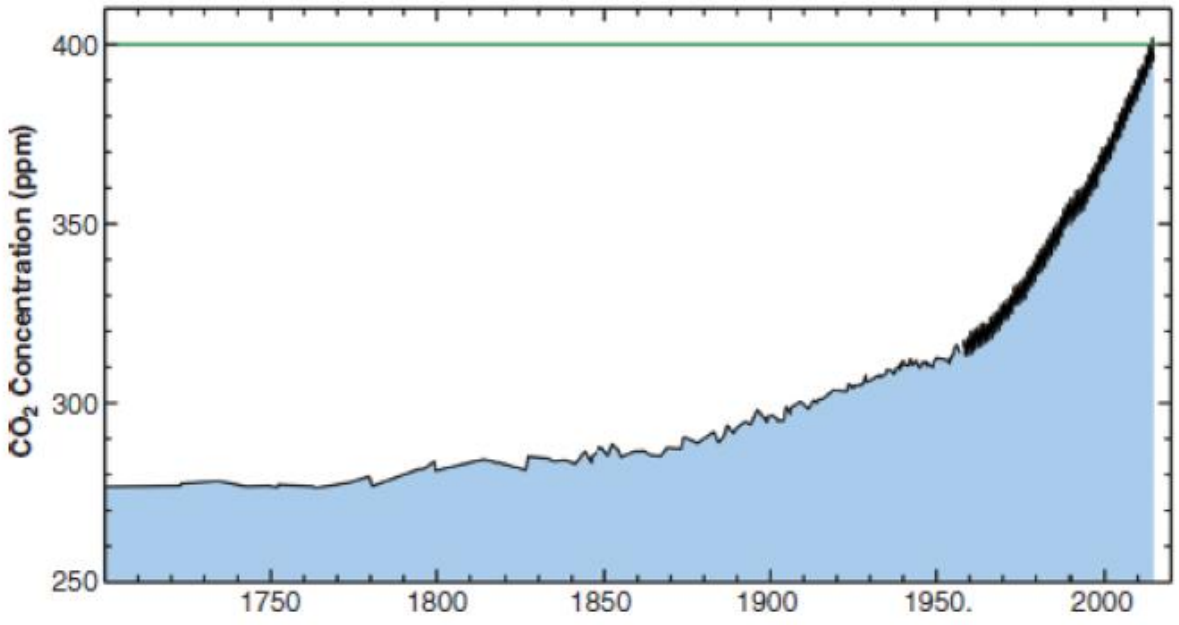
27th to 29th July 2023

The grave problem due to industrialization of the world is too much CO_2 emissions



CO_2 concentrations in Earth's atmosphere from the year 1700 to the present, showing the increase in levels from about 280 ppm to 400 ppm. Note also the acceleration in CO_2 levels since the 1950s.

The philosophy

- In Sri Lanka, the labour cost is about 30% of the material cost
- Hence, save material as much as possible
- Breakaway from the perception that only one brick thick walls are strong (200 + 15 mm plaster on both sides giving 230 mm thick wall)
- We can have 150 mm thick walls stronger than one brick thick walls if high quality hollow blocks are used (lighter weight materials)
- The slenderness effects can be minimized with a special selection of load transfer mechanism
- We must try to minimize carbon foot print by reducing the embodied energy (energy needed for extraction, manufacturing, transportation, etc.)
- Hence, Lightweight Hybrid Multi-storey construction

The foundation and compacted soil fill

Cement stabilized earth base to receive concrete screed

L shaped 300 mm x 150 mm column
L shape reduces the bucking tendency

Tie beam of 100 mm thickness on the rubble foundation with 2H8 bars

Cement soil mix of 1:25 used for cement stabilized rammed earth floor base and finished by compacting the chips and 20 mm aggregates into it

Keeping the rammed earth base moist to ensure a faster gain of strength

Marking the levels on concrete measuring from the string held firmly at the pre-established levels marked on columns

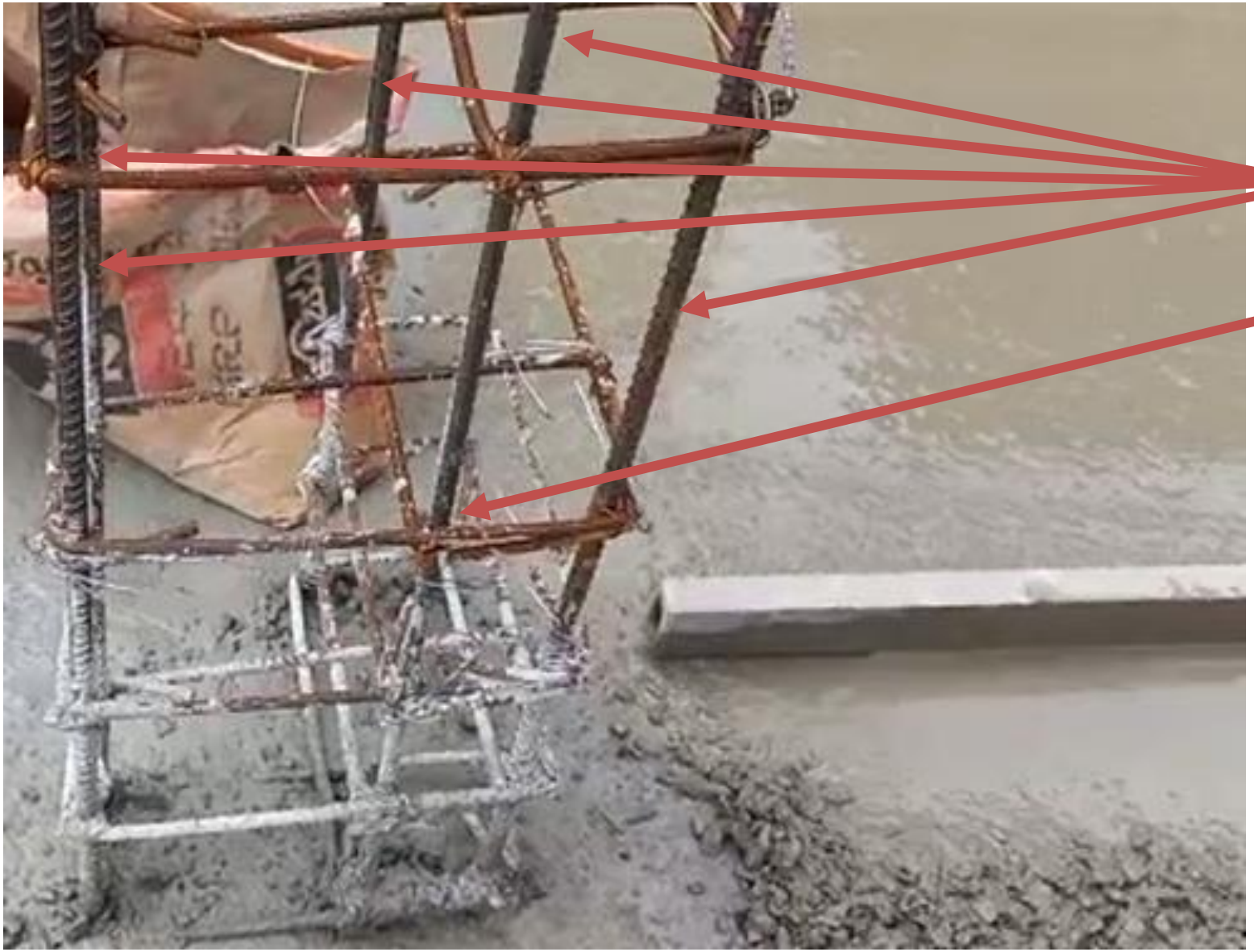
Marking the top level of the floor on freshly placed concrete (admixture has been used to reduce the water content of concrete) – two numbers of 8 mm QST bars also can be seen

300 mm x 150 mm L shaped column has a greater area than a 225 x 225 mm column with much less tendency for bucking – Hence reinforcement can be minimized since vertical loads are carried by the concrete – Reinforcement is 5 Nos of H10 bars and 1H8 – H10 is the minimum size allowed in Eurocodes

Column with 5H10 and 1H8 and tie beams of 100 mm thickness connecting the columns with 2H8 bars for enhanced earthquake resistance

Wash room areas left without a concrete finish

Almost perfectly leveled concrete surface
It can be cut with a terrazzo cutter to give a terrazzo finish or
Tiles can be laid directly on it



L shaped columns are provided with links at 100 mm centers at the floor level and then at 200 mm centers to comply with 20 x bar diameter rule while ensuring a greater confinement in the plastic hinge forming locations (for enhanced earthquake resistance)

Ground floor concrete completed covering all the rubble work to prevent any termite attacks

This floor is ready to receive tiles directly without needing any screed to correct any leveling mistakes

A good example of reducing the number of operations needed to complete a task while using a minimum volume of concrete

The 150 mm thick hollow blocks used for 150 mm thick walls manufactured by ICC

Blocks are laid so that a full number of blocks will be needed for a wall

The size of openings are adjusted to ensure either a full number or a fraction that can be cut from a block

The length of block wall shall be selected to minimize the wastage

Larger half at this end

Smaller half at this end

Size of opening adjusted to ensure full blocks in a row

A wall with a minimum wasting of blocks
The L shaped column that can be completed flush with the 150 mm thick hollow block wall
Hollow blocks laid perfectly vertical and straight to be finished without plaster, but with a cement based putty (skim coat)

L shaped column with a larger concrete area (67500 mm^2)
Hence, reinforcement is needed only for a nominal flexural capacity
Almost all the axial loads taken by the concrete

L shaped columns after placing of concrete
The columns are finished flush with the 150 mm thick wall
This wall can be finished with a cement based skim coat

A beam-slab system is used instead of a solid slab
It is light weight and loads are distributed to all four surrounding walls
Hence, beams carry less load and hence lightly reinforced
In this hybrid system, block walls share about 50% of the vertical loads

The beams are constructed as 200 mm or 400 mm height
The height of one course of finished block wall is 200 mm
Hence, beams shall be of height in multiples of 200 mm
The beam has links at closer spacing at the support for a greater shear capacity and earthquake resistance
The column links within the beam height can reduce the chances for joint failure during an earthquake

Lintels completed for a height of 200 mm and a width of 150 mm

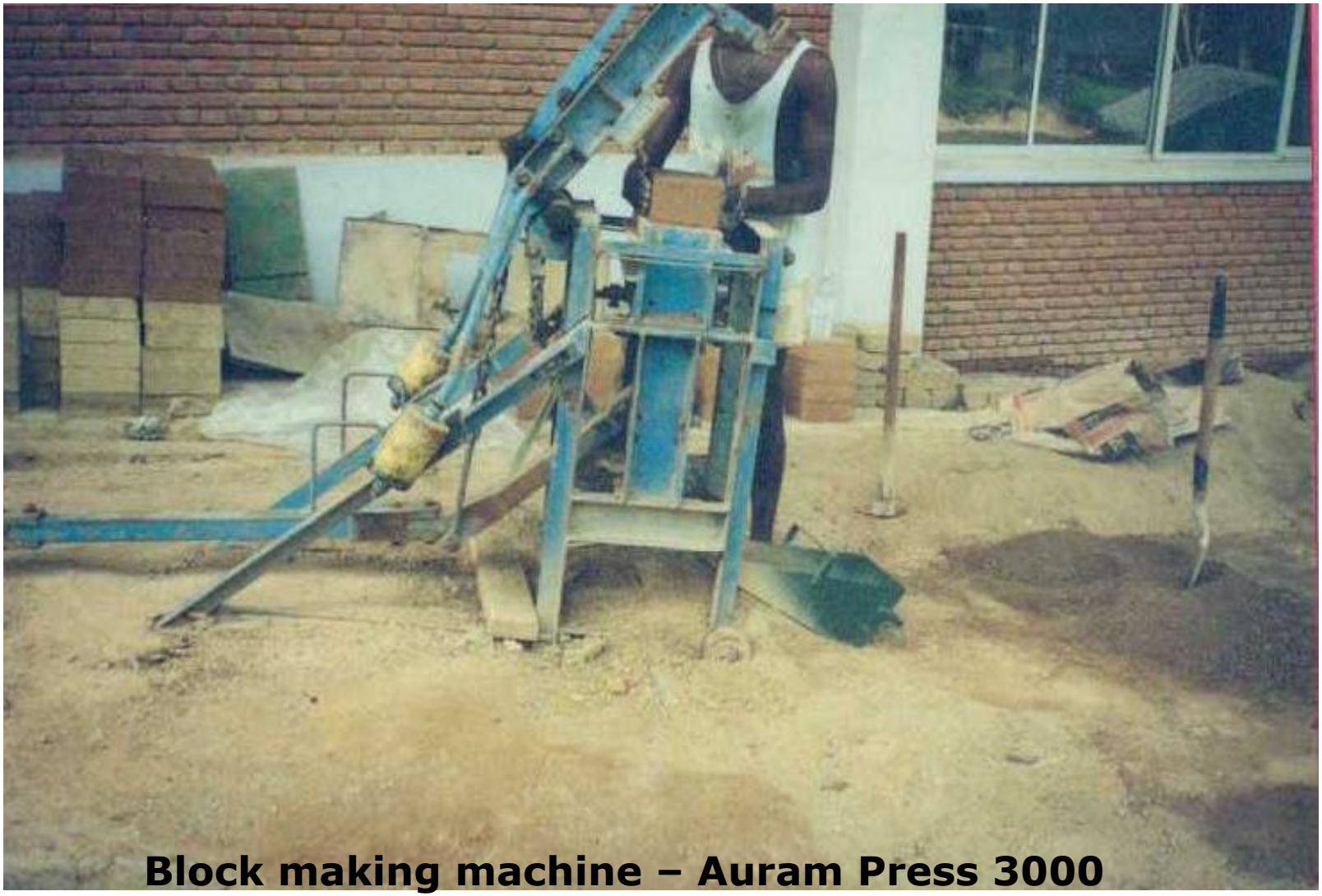
Walls ready to receive 2-3 mm thick cement based skim coat
The completed thickness of the wall is about 155 mm
Walls shall be constructed with the aid of a gauge rod to ensure a very high degree of dimensional accuracy

The walls finished with a cement based skim coat
This material can be used both internally and externally

Locally manufactured cement based skim coat (MACO Super Plaster - 0772400422)
Wet the wall in the previous day to facilitate the application of the plaster without rapid drying

Application of second coat after 3 to 4 hours
Use a straight edge placed vertically to detect the depressions
Use the second coat to make good the depressions

Manufacturing of solid cement stabilized soil blocks with Auram Press 3000 machine (Compaction Ratio of 1.65)



Block making machine – Auram Press 3000

Load testing of lightweight beam slab system with sand bags weighing 25 kg each

A load bearing wall house with solid Cement Stabilized Earth Blocks supporting a lightweight slab system

A three storied house constructed with Cement Stabilized Earth Blocks as an infill material finished with un-plastered walls and Micro Concrete Tiles for roof covering

Micro concrete roofing tiles

Testing of blocks for durability

Application of solid cement stabilized earth blocks in exposed areas with surface coatings in multi-storey buildings

A boundary wall with Cement Stabilized Earth hollow block columns and stabilized rammed earth

Conclusions

- **In Sri Lanka, over the last 50 years, the western construction practices have been used a lot**
- **However, those are tailor made to suit extremely high labour payments**
- **In Sri Lanka, materials are much more expensive than labour**
- **Hence, precise construction practices that can allow the reduction in a material usage while allowing reducing the number of operations needed to achieve the finished product can enable cost savings up to 50% or more in a multi storey house, apartment block or commercial building**
- **Use of less materials resulting in lighter weight has the potential to reduce embodied energy and carbon foot print**

Thank You