TECHNICAL ENQUIRY
ABOUT CEMENT MORTAR MIX FOR SCHOOL BUILDING

DEW Point
DEVELOPMENT RESOURCE CENTRE
ENVIRONMENT – WATER – SANITATION

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Enquiry A0128 - Cement mortar mix for school building

Description

Please could you help our relief team in DRC who are needing to reduce materials cost on an ECHO-funded school buildings project. They want to do this by altering the building method - see options below:

OPTION 1: Build the school using mortar mix for brick masonry on the basis of the following mixture = 250kg/m3 Sand with a proportion of 75% cement and 25% lime. Does that mixture seem correct to you? Same question for external “crepissage” (rendering?) on the basis of the following mixture = 300kg/m3 sand with a proportion of 75% cement and 25% lime. Does that mixture seem correct to you?

By mixing lime with cement we could save some money, but would like to have your technical advise to know if the mortar mix could be a valid option and if the mixture proposed would be correct and solid.

OPTION 2: Use mortar mix + cement blocks instead of baked clay bricks for the construction. More expensive but we would save money on transport as we can make the cement blocks in the field whereas we will have to transport the bricks from far.
Here our watsan team has suggested to build the schools using mortar mix for masonry on the basis of the following mixture = 300kg/m3 sand (instead of 250kg/m3 in the 1st option) with a proportion of 75% cement and 25% lime. Does that mixture seem correct to you? Same question for external “crepissage” (rendering) on the basis of the following mixture = 350kg/m3 (instead of the 300kg/m3 in the 1st option) with a proportion of 75% cement and 25% chaux. Does that mixture seem correct to you?
Also for the cement blocks construction the team suggests to use 1 bag of cement (50kg) to make 32 blocks 15x20x40cm.
Does that seem correct to you?

All we need is your technical advise on:

- the different kind of mixtures to ensure that if we try to reduce to save money it will be still solid
- the best cost-effective option for construction: mortar mix or pure cement mortar, and baked bricks or cement blocks?

Technical response by Practical Action (www.practicalaction.org)

The suitability of each option will depend on the design of the school building, a single story school could be constructed from compressed earth blocks or stabilised soil block without any difficulty. And with mortars and renders there are a number of low cost options that should be considered before going for the expensive option of cement based materials.

Building Blocks

Soil Blocks

This option is one that Practical Action has used widely and is one of the most cost effective options as construction can be carried out locally without large amounts of cement that are often expensive or not available. It will be cheaper than cement blocks and clay bricks. Soil blocks can include a percentage of cement to ensure its stability. Between 10 and 15% is used.

Concrete blocks

A good example of cement blocks comes from Development Alternatives in India. The size of solid concrete blocks is 300x200x150mm. The basic raw material is cement, fine aggregate and coarse aggregate. Very little water is used. This is possible only with mechanized compaction and vibration and gives the block high quality in spite of the lean mix, which uses very little cement.

Typical size 300 x 200 x 150 mm
Average compressive strength at 28 days 50-110 kg/sq.cm
Mix Proportion 1:12-14 (1 part cement: 12-14 parts sum graded aggregates)
Water absorption in 24 hours Less than 10% by weight of block

By comparison the SBS block making machine from the USA uses a ratio of 1 to 11

> "The ratio of cement, sand and stone chips or gravel in the raw material mix determines the properties of hollow concrete blocks. A ratio of 1:3:6 [cement: sand: stone chips] confers higher strength, while a ratio 1:5:6 can be employed for normal load bearing construction. The water to cement ratio is usually 0.4:1, which is a little less than half the amount of water to cement."

If using a ratio of 1 to 12 then you will be able to produce 650kg of material. The weight of the Development Alternative concrete block is about 18-19 kgs, making approximately 34 blocks. These blocks are slightly smaller than the ones you propose, therefore you would get slightly fewer blocks for the same amount of material.

Hollow cement blocks are widely used and help reduce material requirements. There are many block making machines that produce hollow shaped blocks. They are lighter than bricks, easier to place and also confer economics in foundation cost and consumption of the cement.
http://www.appropedia.org/Concrete_Block_Producing_Equipment_3

Another option used by Human Settlement Division of the Asian Institute of Technology amongst others is the interlocking block which reduces the amount of mortar that is required to construct a wall.

This can also apply to stabilised soil blocks. Practical Action South Asia sued interlocking stabilised soil blocks. And the Development Technology Unit at the University of Warwick has carried out some research on this topic

Mortars

A typical lime / cement mortar for general building (above ground) would have a ration of sand, lime, cement of 5:1:1. Below ground would use a ratio of 6:1:1. The internal walls would be in the ratio of 9:2:1.

By comparison a cement mortar for a one story can be of the following ratio:
1 part Portland cement to 5 to 8 parts sand plus water

There are a wide range of alternatives to Portland cement used as mortars, renders and non structural concretes. The most common is lime which can be used in combination with pozzolanas materials to improve its strength. Pozzolanans materials include volcanic ash, power station ash, burnt clay, ash form pants, silicious earth materials. Other materials include gypsum, sulphur, bitumen, earth/clay and animal dung. These mortars are suitable for one story buildings are can help reduce the cost of construction by reducing or eliminate the demand for cement.

Some example of alternative mortars mixes are outlined below:

120 litres of sand
40 litres of lime (300kg/m^3)
Water

225 litres of soil
50 kg of cement (225 kg/m^3)
2,8 litres of bitumen cut-back (1%)
Water

60 litres of soil
1,6 litres of bitumen cut-back (2%)
Water

A good mortar for a one story building wall can be made from the following ratio
400kg of hydraulic lime
1m^3 sand
Plus water

[Appropriate Building Materials, Roland Stulz, SKAT/IT Publications] Other mortar mixes are listed in this publication.

Renders

A typical cement / lime render would be:

Hydrated lime should not be more than 15% of the cement's volume
5 parts sand
2 part Portland cement
Water
The same basic mix is used for all layers, but the final layer should contain more lime than the sub-layers.

Although renders can be as diverse as the mortars outlined above so a low cost approach would be to use mud renders. These can have various additives that make them more stable. Practical Action has a technical brief on the subject on its website amongst other documents on limes and alternative mortars.