Basic Technology: Gypsum, its production and uses

This article is the second in a series dealing with basic technologies for the preparation and use of indigenous materials in construction and related fields of design. Alvaro Ortega is currently preparing a book devoted to this subject and here shares fundamental facts about gypsum. Presented in a straightforward way, MIMAR hopes that these articles will directly aid in diffusing know-how to potential users of these technologies.

Why gypsum is a good material

The small scale production of binding agents will help countries with “economies of subsistence” to provide their needed low-cost shelter.

Portland cement, lime, gypsum and sulphur are some of the best choices. Unfortunately cement is not economically affordable in most underpaid countries. In addition, due to transportation costs, cement price doubles every 500 kilometres or so of distance. To buy one bag of cement requires, in many cases, the rural salary of up to one week’s work. The cost of a binding agent may represent up to thirty percent of the total construction costs of a small house.

Rural communities should take advantage of their local resources such as limestone, gypsum, sulphur and pozzolanic material as sources of energy like coal and renewable biomass energy for the improvement of their habitat.

Gypsum has many advantages:

- It uses natural resources produced locally (with no need for outside financing).
- It is a good binding agent; is quick-setting and needs no formwork.
- It has good fire resistance and good heat insulation.
- It gives a superior finish.
- But: It is only useful indoors if protected from humidity.

History

Gypsum is a very important binding agent used as building material since ancient times. Its use as a fire-proof material was demonstrated in Europe after a series of big fires in cities occurring at various times between 1200 and 1800 when Paris, London and Basle were almost totally destroyed by those fires.

Also the Baroque architecture of the eighteenth century could not have been built without calcinated gypsum.

Gypsum is the most common sulphate mineral and can be broadly classified into natural and synthetic.

The prime consumer of gypsum is the cement industry. Gypsum occurs in extensive beds associated with other evaporite minerals; it is deposited from ocean brine and saline lakes.

Gypsum also occurs disseminated in limestones, dolomitic limestones and some shales. Gypsum deposits occur in many countries of the world. It is one of the first minerals to crystalise as seawater evaporates. Lake Assal in the Republic of Djibouti is a very good example on ways that gypsum is produced by evaporation of salt water. North Africa possesses major reserves of gypsum on the Mediterranean coast, along the Gulf of Suez and the Red Sea.

Somalia has one of the largest known gypsum deposits of the region. Several countries in East Africa; Madagascar and Mauritania have further reserves of great interest for use in house construction. Among the countries in Asia with abundant gypsum resources are: China, India, Korea, Afghanistan, Pakistan, Thailand and Iraq. In Japan and the Philippines the gypsum natural resources are scarce but chemical gypsum is becoming to be available in large quantities in both countries.

Properties of gypsum

The outstanding advantage of gypsum plaster is the fast setting. There is no long term curing reaction as is the case

Gypsum often occurs as well-formed crystals that sometimes attain a large size. The primastic crystals are transparent to translucent and have a glassy lustre. Gypsum is one of the first minerals to crystallise as seawater evaporates. It is also found in volcanic areas.

At Lake Assal in the Republic of Djibouti, 160 metres below sea level, is one of the areas rich in resources for the production of building materials such as gypsum, lime, perlite, diatomite and basaltic stone. Other countries with considerable gypsum deposits are: Iraq, United Arab Emirates, Cyprus, Somalia, Tanzania, Kenya and Jamaica.
Gypsum is used as a building material in construction. Cast gypsum is formed by placing a mixture of water and a powder, which is anhydrous calcium sulphate, into a mould. When the cast is hard for lifting, the mould is free for refilling. The absence of slow curing reactions means that the cast can be dried out almost immediately after it has been lifted from the casting bench.

Gypsum can be obtained as a by-product from sea-salt waste, phosphoric acid, and Grober-salt’s gypsum. Gypsum is a by-product of the chemical industry and an industrial waste. Examples include: Sea-salt gypsum, Refinery gypsum, Phosphoric acid gypsum, Grober-salt’s gypsum, and synthetic gypsum.

Gypsum board is easy to handle and has a sound absorption property of great interest for wall and ceiling construction. The second type is formed by a process of partial dehydration and is subject to heat and moisture. Lightweight aggregates like vermiculite, perlite or pumice mixed with plater produce a stronger material as well as efficient sound absorption surface.

Production Today
Small-scale production could be of great use for improving housing conditions in rural areas. The transformation of gypsum to plaster is still carried out in masonry kilns—two examples are illustrated.

In Mauritania, where there are large deposits of gypsum, the United Nations Centre for Human Settlements participated in demonstrating the use of solar energy to transform gypsum to plaster as a cottage industry.
The calcined material should be ground fine for enabling more contact during wetting and setting. A finer plaster of Paris when wetted sets in about three minutes at a temperature of 22°C whereas the  unground material does not harden for about fifteen minutes. It is not recommended the grinding of gypsum before calcining it, as its structure is suitable for allowing the water vapour to escape during calcination. Experiments could determine best proportions of plaster, fine aggregate and coarse aggregate for the various uses.

The quick setting of plaster gives advantages when used as binding agent for the construction of arches, vaults and domes using brick and tiles. This construction technique is used in the south of Spain and north Africa where roofs are built without any formwork. The two to three minute setting time makes possible the use of this economical building method.

Determination of Properties.

1. Expansion of gypsum plasters. The linear expansion of plaster is one important property to be measured. The best indicator is after a period of 24 hours.
   The plaster extensometer is 100 mm long × 60 mm wide and 25 mm deep. It is closed at one end and open at the other. The expansion of the specimen is shown on the dial gauge.

2. Pat test for soundness of hydrated lime and gypsum building plasters. A sound plaster is one that shows no tendency to expand after it has been in used after some time.
   For this test a brass ring mould, 100 mm diameter × 5 mm deep is used. The mould has an internal taper of 5.0. A glass baseplate is also required.

3. Setting-time. This procedure has been designed to determine the setting-time of gypsum-plaster and its relation to the quantity of water used.
   This test is important when the material will be used as binding agent in the construction of arched roofs that avoid any formwork.
   The penetration of the needle will indicate the consistence of the material at several minute intervals.

To produce plaster of Paris a temperature of 110°C is necessary and a partial dehydration takes place as calcination proceeds. Anhydrous sulphate plaster requires over 170°C and is the result of complete dehydration. It is difficult to reach the temperatures required for the time needed — for example the solar-still (shown as an example) cannot achieve this temperature.
Gypsum has been used for many years as a building material in the Mediterranean and Middle-East countries. It was introduced into Europe in the 13th century as a wall plaster.

Where do we find gypsum deposits?
Large deposits of gypsum occur around the world: most countries in Europe, Canada, Mexico, USA, South America and North Africa. There are also major reserves of gypsum on the Mediterranean coast, the Gulf of Suez and the Red Sea. East Africa and Madagascar have further reserves. The geological survey office, in most countries, may be able to help in providing information regarding gypsum deposits in your area.

Which are the main uses of gypsum?
Raw gypsum is used:
• In the production of portland cement as retarder.
• In agriculture for promoting the growth of vegetables.
• In the manufacture of plaster for producing building components.

It is quick setting and has fire-resisting quality.

How is plaster produced?
Plaster is derived from the calcination of gypsum at a temperature of 120°C. It is possible to use solar energy as heating source.

Which are the advantages for using gypsum in building?
• It is easily converted in a cementitious material.
• It is quick setting and eliminates the need for formwork.
• It has fire-resisting quality and heat insulation.
• It is a good sound absorbing material.

Apart from the use of gypsum plaster as a binding material a variety of products may be manufactured like: wall blocks, panels, slabs, acoustic tiles, plaster-boards, casting forms.

Countries with gypsum deposits could manufacture many building components without the need of large capital investment.

Gypsum products can be used externally in countries having moderate rainfall since gypsum dissolves in rainwater. In designing for high intensity rainfall areas, provision should be made for a rapid run-off from both roof and site, the foot of buildings should be protected against erosion and good house ventilation should be provided to assist the drying out speedily after rain.

Basic Questions
What is gypsum?
It is one of the softest sedimentary rocks, occurring in crystalline form, sometimes in nearly transparent shapes. It is one of first minerals to crystallise as sea water evaporates.

Since when has gypsum been used as binding material?
It was used in Egypt over 4000 years ago and was a traditional building material for the construction of many temples such as the Pyramids.

Uses
The use of plaster of Paris as moulds for casting concrete for building structures has wide applications. The Institute for Building Construction of the Technical University, Budapest, Hungary, has been working on this. In their system the moulds are left in place, eliminating the need for a finished surface and reducing the cost of formwork. In addition, any gypsum surface that comes in contact with humid-fresh concrete helps to absorb the unnecessary water in the mixture giving additional strength to the structure.

A large number of fibres, both natural and artificial can be used as reinforcement. Sisal has shown itself to be unrivalled for the production of fibrous plasters. To ensure that fibres are kept away from the surface a layer of plaster about fifteen millimetres thick is applied to the mould and allowed to harden before the bulk of the plaster is cast.

The gypsum plaster consists of about 100 parts of calcined gypsum and 70 parts of water by weight.

The gypsum industry consists of two distinct activities:
• The mining and calcining aspect.
• The casting and fabrication of building components.

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