



Wall Building

Technical Brief

Building Advisory Service and Information Network

Using Stone for Building: Facts and Fads

Introduction

The "facts and fads" in this technical brief have been selected to provide a better understanding of the properties of stone and their application in informal building.

Stone Mysticism

Few natural building materials are misunderstood as is stone. Firstly the definition of stone; then the "mystical" part played by stone - from the time when our planet was formed, and stone's many uses realised by man - up to day with its applications in various forms.

Stone has "played its role" in the planet's history. The rational and technical use of stone began in the middle ages when stone working guilds were formed, with their different activities fully recorded. However, mysticism never really diminished and "trade secrets" perpetuated, thus creating fads. Technology, unlike mysticism has finally encouraged the popular use of stone.

Stone Technology

"Stone technology" as it is known today, emerged after the second world war. Standards are presently under constant review by the standardisation community, notably the CEN (European Committee for Standardisation) in Brussels, Belgium, with a complete EU representation. In 1999 the first CEN stone standard tests were approved by public enquiry. They are to be made public in 2000, after a deliberation which started as far back as 1994, finally translating the fads into facts, especially concerning stone properties.

Many facts emerged in that period, and gradually assumptions are being straightened out. Opinions vary how the CEN findings are affecting developing countries with their informal building practices. These will have to be monitored, especially safety aspects which cannot be compromised. Streamlining stone application procedures still awaits attention.

Stone Materials

The term stone describes a material which is often confused with "rock", which to the geologist is any naturally formed aggregate or mass of material constituting an essential and appreciable part of the earth's crust. To the geographer and morphologist, the word rock signifies a peak, cliff or promontory, such as the "Rock of Gibraltar" or the "Sugar Loaf" in Rio de Janeiro (Fig. 1), while to the engineer rock denotes a firm and consolidated substance that cannot normally be excavated by manual methods alone.

There are other uses for the term rock, mainly of a local nature: in some mining areas, rock denotes crude ore; in quarry working, massive stone is called rock, and the list goes on.

What then is stone? Stone is rock material. That is a fact. Rock becomes stone after extraction, especially after diminition, that is, breaking up.

The term stone is applied commercially to all natural rock materials quarried or mined, for constructional and sometimes industrial use. This technical brief is concerned with stone for building.

Construction Stone

Construction stone is intrinsically a hard and consolidated structural material. Normally loadbearing materials, such as burnt bricks, and other rock materials like the softer clays, require processing to become hard. Lightweight aggregates, shale and marl need to be converted to form cement and so on.

Marble, limestone, dolomite, granite, sandstone, basalt, quartzite, slate, tuffs are some of the geomaterials used for building stone and at the same time represent classes in which a variety of geological or industrial stone names are found.

The lack of agreement on basic terminology can lead to all kinds of confusion. Industrially, the term "marble" is applied to a wide range of stones capable of taking a polish, although such stones can also be used decoratively unpolished, as in the case of travertine.

Many types of travertine have properties akin to building stone. There are building stones on the market which, if polished, would satisfy the most exacting definitions applied to and associated with marble. All marble is stone, but not all stone is marble!

In its wider sense, dimension stone (including marble and other rock varieties) can have coarse and often uneven surfaces. However, definitions applied to dimension stone differ from country to country and even from region to region.

Fad: *Stone is a durable material* - Fact: *It is.*

This depends, however, on environmental factors, the use it is put to, the climatic effects, the selection and care in workmanship - whether during quarrying or in the applied building techniques. Soft rocks can last millions of years if undisturbed in situ. Problems, however, start when soft rocks are removed from the site. Then many changes occur:



Fig. 1: The "Sugar Loaf" in Rio de Janeiro, Brazil

- loss of strength,
- change of colour,
- opening of stylolites and other structural alterations which weaken the stone, especially when it is used in paving, where impact and loading is common as opposed to walling.

Stone is a durable material when properly selected and applied.

Fad: Stone improves after quarrying - Fact: It does.

This depends, however, on selection. A good quality soft stone acquires a protective and hardened skin on exposure. Even the rigid acceptance conditions of the ASTM (American Society for Testing and Materials) have taken this into account by requiring different minimum acceptance parameters for soft rather than hard limestones.

Fad: A weathered stone is a "sick" stone - Fact: This depends on the stone variety.

E.g. weathering of basalts may take place rapidly for some period and then slow down. This process is considered "healthy" (resulting in a sound stone). It has also been observed that other basalt varieties weather slowly at the beginning of exposure, and thereafter the rate of weathering speeds up. This disparity happens because the first mentioned basalts had already weathered before placement. As a matter of fact, surfaces of some most intensively weathered stones which found their way into

rivers or coastlines, are being cleaned by the river water and sea waves and provide high quality building stones.

An important factor to be considered in stone weathering is its mineral composition. Stone is sound if its minerals are not affected by weathering. Slight weathering takes place if only a part of the minerals have been affected, and the healthy minerals are in contact with each other. A stone is considered totally weathered when most of the minerals are affected, and the healthy minerals are no more in contact. Then disintegration sets in and may for example turn the stone into a clay as is the case with "sick granite" (which can change into a kaolin this way), or ultimately turn into soil. Weathering of a healthy stone can add character to a building. Sick stone leads to decay!

Fad: Colours of stone do not change - Fact: Although colours of stone remain unchanged after dressing, the chemicals used in surface treatment (in the polishing process) can darken the stone, because light value decreases.

Depending on the polishing medium used, chemical bleaching can also result. Red minerals in granite become gradually lighter coloured on exposure to light. Hydration during environmental weathering converts minerals like hornblends and pyroxenes from green to black into brownish colours.

Fad: Stone is not marble - Fact: Not correct.

As already mentioned above, a marble is by geological definition a metamorphic rock, a term which is seldom used by the stone practitioner. Commercially most building stones and slabs with a polished surface finish are marketed as marble, whether of sedimentary, igneous or metamorphic origin. Stones which do not take a polish can still have an ornamental effect with honed or ground finishes besides the various dressings applied with chisels and other percussive dressings. Since all marble is stone, although not all stone is marble, the fad is incorrect.

Fad: Stone waste causes "scavenging" problems - Fact: No stone needs to be wasted.

When there is waste or "leftovers" from sizing and/or dressing stones, this can be crushed and used for aggregates, etc. (Fig. 2). Unusable stone pieces can also be used for fill. Depending on its quality, it can be used for industrial purposes, or e.g. for lime burning in the case of calcareous stone. Stone is always recyclable in one way or another.

Fad: Granite is more difficult to quarry and process as are carbonate rocks - Fact: No.

The term "granite" when used to describe a building stone refers to a whole range of igneous rocks, most of which have directional properties absent in the carbonate rocks. Whereas they may lack true bedding and layering properties as in sedimentary rocks, igneous rocks have vertical planes of easy cleavage or breaking and can be split into building stone units comparatively easy. They are not affected by karst, stylolites and other solution features in fresh outcrops or in river boulders as are limestones. These properties compensate the longer working time needed for their extraction and dressing. Another reason for the fad is that in most parts of the world granite was little used till the 15th century and then mainly for building churches and castles, with exceptions of the terrific stone structures put up by the Indio-Americans in the Andes of South America long before.

Fad: Blasting damages stone during extraction - Fact: This depends on the use of the stone.

Natural stone is also the basis for concrete and other conglomerated crushed stone products. Blasting damages are not questioned when aggregates are produced. Dimension stone is carefully extracted. Various breaking methods are used to remove blocks from an outcrop before further subdivision. A white expansive powder achieves the effect of blasting without using explosive. This powder is marketed under various trade names (e.g. Britex) and breaks stone by expansion. It is gradually replacing the traditional black blasting powder.



Fig. 2: Stone aggregate production from waste

Fad: Thickness of stone is not important, soundness matters - Fact: This depends on the use and application.

True, the physical properties of thin and thick stone are the same and together with the thickness of the binding material form a monolithic unit, which makes up for any thinness. However, there are also other factors like moisture retention, or incipient cracks which increase with time when thin stone is used as a cladding-skin or for flooring. Conversely, thick building stones with strong mortar are bound to get damaged in earthquakes and/or cracked on strong impact. Again, repeated dressing of a thin stone surface, e.g. to prevent slipperiness, can weaken the stone, especially when subject to thermal treatment.

Fad: Stone as a building material is expensive - Facts: This depends on its local availability.

Stone can be a prestigious material, and at the same time constitute an economical and affordable structural and/or decorative building material. This entirely depends on its local availability, often even at the actual building site. A radius of 10 miles distance from the source of stone to the site has shown to be economically feasible for its use in housing projects.

Fad: Stone building requires special skills - Fact: No.

An old technique of using long shallow portable wooden forms, set facing each other ensures the desired thickness of the walls, besides providing straight, smooth, plumb sides of the building. This method is still practiced for building one- or two-storey stone houses in the Middle East. There are several variations of this building technique.

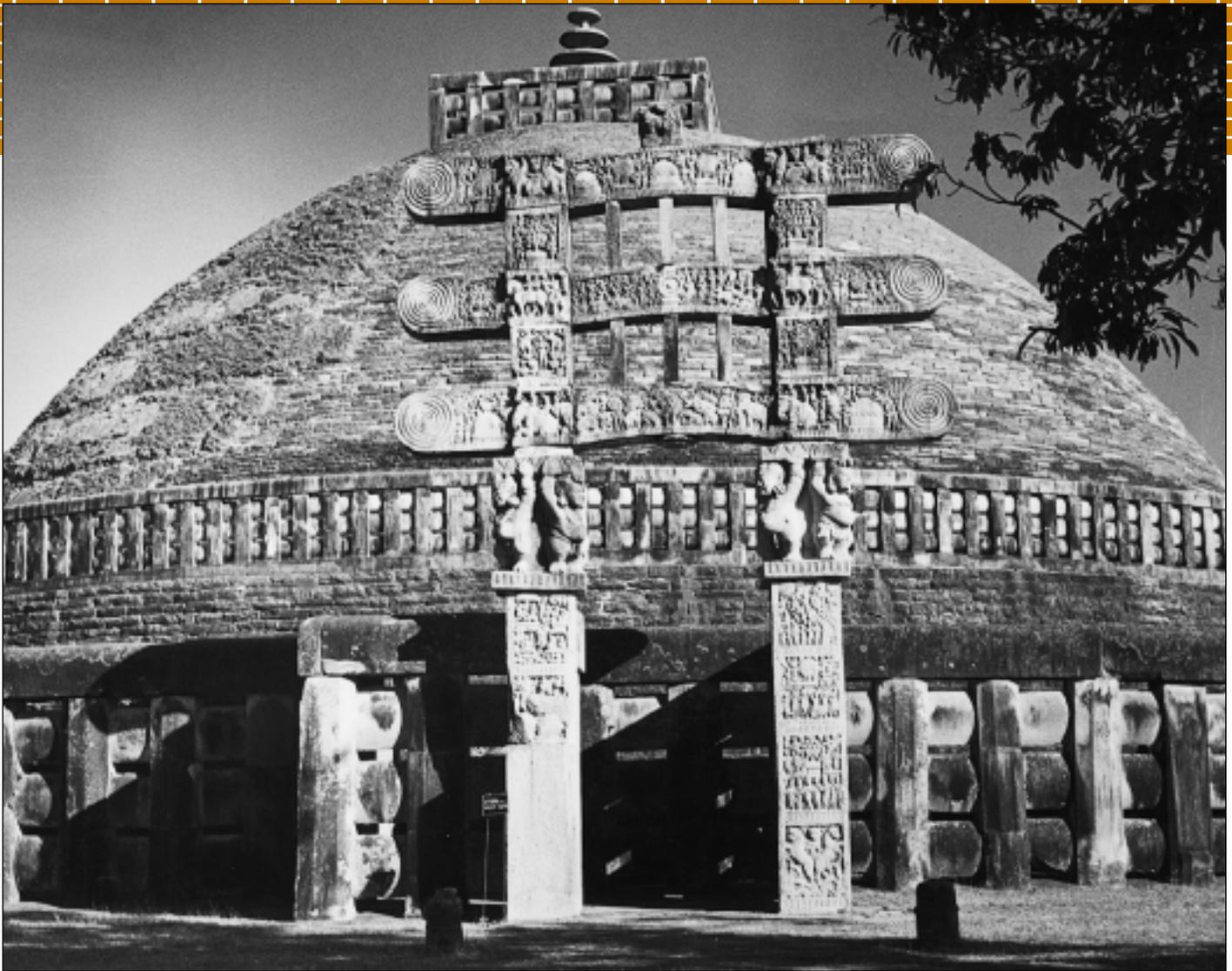


Fig. 3: Woodworkers techniques used at the Stupa in Sanchi, India, built about 2000 years ago

Fad: Stone is more difficult to work than wood - Fact: No.

This fad comes from areas where there is still plenty of timber and natural fibre material available for use in building construction. In Fiji, a local group of renowned Pacific woodcarvers were asked to use the stone found around their village as a carving material. They declined, replying that the necessary tools were not available for this, not realising that the tools they use for wood working and carving, a mallet or hammer and chisel, could also be used for working with the material called stone. Stone carvings at the Konarak Sun Temple in India are only one of several examples which show the adaptation of woodworking techniques to working on stone material (Fig 3).

Fad: Stone quarrying is costly - Fact: This depends on the techniques used for quarrying.

In quarrying, a large boulder can be lifted by heavy equipment or by 2 men using levers and gradually heaving the boulder up. One man shovels sand or other small boulders while the other packs it into the void created by levering the edge. This is just one of many simple methods for moving stone. And it is an age-old "quarrying technique" (Fig. 4).

Fad: The use of stone for building requires high investment - Fact: The investment depends on the availability of labour and appropriate stone working methods.

Where stone is available in a natural form like boulders and slabby stone from deposits capital investment for extraction of the raw material is just required for the labour and haulage. Appropriate stone working methods can easily be acquired by training, if they are not known. Know-how on making use of simple tools like levers, hammers, chisels and lifting tackle can be transferred and disseminated locally.

Fad: Building with stone is "time consuming" - Fact: No.

Compared with the use of other locally available building materials stone does not take more time. It is entirely a matter of planning and adherence to guidelines and simple rules (BASIN/GATE TB 07-09). Laying a stone floor with slabby stone materials may take some days, similar to laying the foundations. Walls of a rural (or urban) low-income house can be completed within a few months, depending on organising the materials flow to the site.

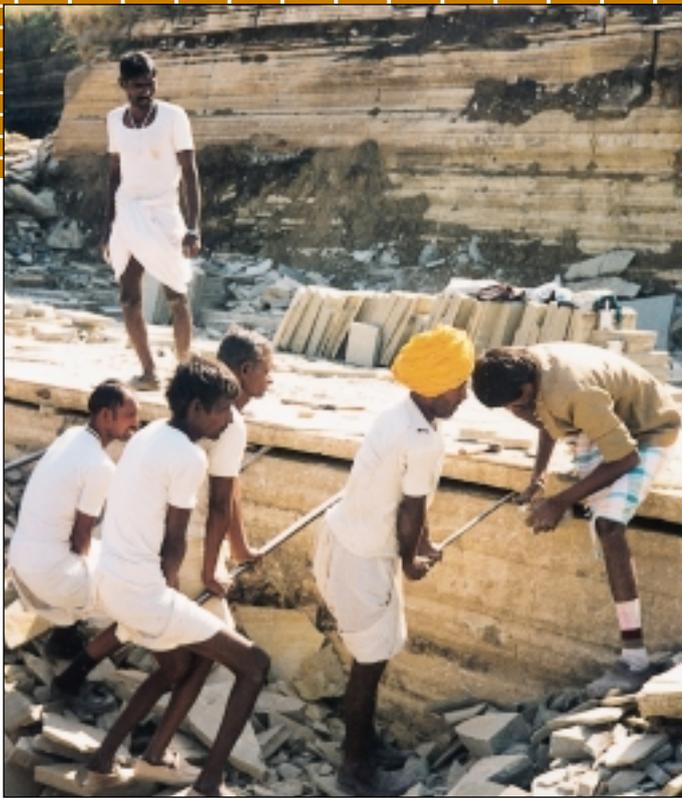


Fig. 4: "Levering" by manpower in India

Fad: Stone working requires large energy inputs - Fact: No.

There are only few other building materials which need less energy, both in manufacturing and application. The production of cement needs a very large energy input besides a large amount of fuel, for breaking down the raw material, and requires complex technologies to turn it into "stone" again, as a monolith. In stone breaking for building, a 10 kg hammer can subdivide blocks weighing more than one tonne. A large stone slab weighing many hundred kilograms can be moved with ease by straddling. Ergonomic ingenuity enabled the ancient builders to put up stone structures which are a testimony to their skills.

Fad: Stone for building requires extensive maintenance - Fact: This depends on climatic conditions at the location.

In a hot and humid climatic condition vegetation growths can affect solid stone walls and cause decay, if these not regularly maintained. This will not happen in moderate climatic zones where a minimum of maintenance is needed, consisting of an occasional washing down of all wall faces to remove external pollution effects (very much like a car needs washing, but less frequently).

Again, soft stones used in external walls can be adversely affected by climbing plants (such as ivy) rather than hard stones, a factor which should be considered in wall construction.

Stone is vermin and insect proof and does not need any external treatment and/ or coatings. If there is a surface deterioration visible, the stone selection was wrong or the workmanship was poor.

Fad: Stone development in the South lags behind that in the North - Fact: This is far from being so.

The development (and promotion) of the stone working industry nowadays is so notoriously slow because of the artisanal structure in an antiquated industry set-up. This applies to the North, where the industry still uses the same methods for stone working which were developed long ago.

Paradoxically in many developing countries more sophisticated and modern stone working equipment is used as compared to small-scale enterprises in some developed countries, where old equipment is still in use. Since this machinery is very sturdy, there is a reluctance to replace it with more modern, yet perhaps more "vulnerable" equipment.

In addition many developing countries base their industrial and economical development on master plans to direct the use of their own resources.

Fad: Standards testing ensures reliability - Fact: For a "manufactured" product = yes.

This applies to a manufactured product. Yet stone sets its own rules which are governed by its intrinsic properties, which are variable even if the stone is extracted from one particular quarry.

In practice stone "testing" results are subject to interpretation by experts and are guided by arbitrary considerations. Standard drafters allow lower acceptance norms for low density limestones than for those of high density varieties, e.g. in compressive strength where the strength ratio allowed is about 1: 5. To the layman a limestone is a limestone.

Fad: Stone walls provide poor insulation - Fact: Yes.

Stone walls heat or cool very slowly because of their thickness. They are self-adjusting to extreme outside temperatures. The inside room temperatures change very gradually after nightfall or sunrise and balance out the temperature extremes. Only a minimum of wall insulation would be needed to counter adverse influences effectively in more extreme climatic zones.

Fad: Stone can be manufactured artificially - Fact: No.

Notwithstanding many efforts throughout the centuries to produce artificial simulations of stone, none of these have succeeded in attaining a product possessing all the positive characteristics of natural stone. Stone transmits a unique aesthetic impression, has a long life, resistance to mechanical and environmental effects of air and water. These characteristics have all contributed to the fact that people nowadays turn again to the "natural" product.



Fig. 5: Sandstone dressing in New-Delhi, India

Fad: Labour-intensive building construction is expensive - Fact: Not in all countries.

Labour intensity can be adjusted to the cost/time factor. Cheap labour often proves to be expensive as skills and incentives may be low and possible corrections are time-consuming. Stonework is repetitive and a skilled worker can obtain a high grade of efficiency which also depends on dedication (Fig. 5).

Fad: Building with stone is heavy work - Fact: No.

The largest parts of common stone sizes used in informal building weigh scarcely more than the average board of timber in wood frame construction. The heavier foundation stones do normally also not require lifting tackle.

What is basin ?

References:

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- 3 BASIN/GATE Technical Briefs (TB 07-09), 1997
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- ASTM (American Society for Testing Materials):
 - C-615: "Specification for granite"
 - C-568: "Specification for limestone"
 - C-503: "Marble (exterior)"
 - C-616: "Specification for sandstone".

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