



Wall Building

Technical Brief

Building Advisory Service and Information Network

The Boulder Concept in Building Walls

Introduction

For some time now small boulders and cobbles, as well as the production of slabs from large boulders are successfully applied worldwide for wall construction and other uses as part of the "Boulder Concept".

Boulders, cobbles and pebbles, sometimes defined as unconsolidated sediments, are a widely available source of structural stone material in informal constructions, apart from their use as aggregates. Boulders are the largest stones of the three kinds mentioned above, starting at a diameter of about 256 mm. Assuming they are of a perfect spherical shape and take 2.70 as the specific gravity, they should weigh 23 kg. The smallest cobble size starts at 64 mm and weighs 3.75 kg. Pebbles, in addition to their use as aggregates, are used for wall decorations. Large pebbles, weighing over 1 kg, are included in a cobble mix. In construction practice the terms are loosely used and boulders may also include larger sized cobbles.

Sources

Large boulders sometimes form eminences large enough to pass for outcrops. Such residual rocks may stand out at the ground level of batholiths and could well be part of igneous off-shoots separated by deeply eroded valleys. Inselbergs, kopjes, knobs, hillocks, monad-nocks, stocks, buttes, bosses are few of the names applied to such features, although these do not imply genetic affinities or connections to the regional mass.

Identification of Deposits

The accumulation of boulders can be of the following kinds and resulting:

1. from marine erosion,
2. from glacier action,
3. from sliding or fault movements (talus deposits),
4. from weathering processes.



Figure 1: "Granite boulders with snecking in La Rioja Province of Argentina"

Origin

Boulders generally result from weathering processes in fractured massive rocks. These accumulations are typical of the crystalline terrains, especially granitic. The boulders have little or no movement or tumble downhill to attain balanced positions. In their original position, even if

not in-situ, identification of directional features and properties like grain directions, textures, splitting directions etc. are facilitated.

Unconsolidated boulder deposits of the fieldstone and riverstone types, glacier accumulations, mountain scree, stones from dry riverbeds, terraces and beaches are used as materials for house building

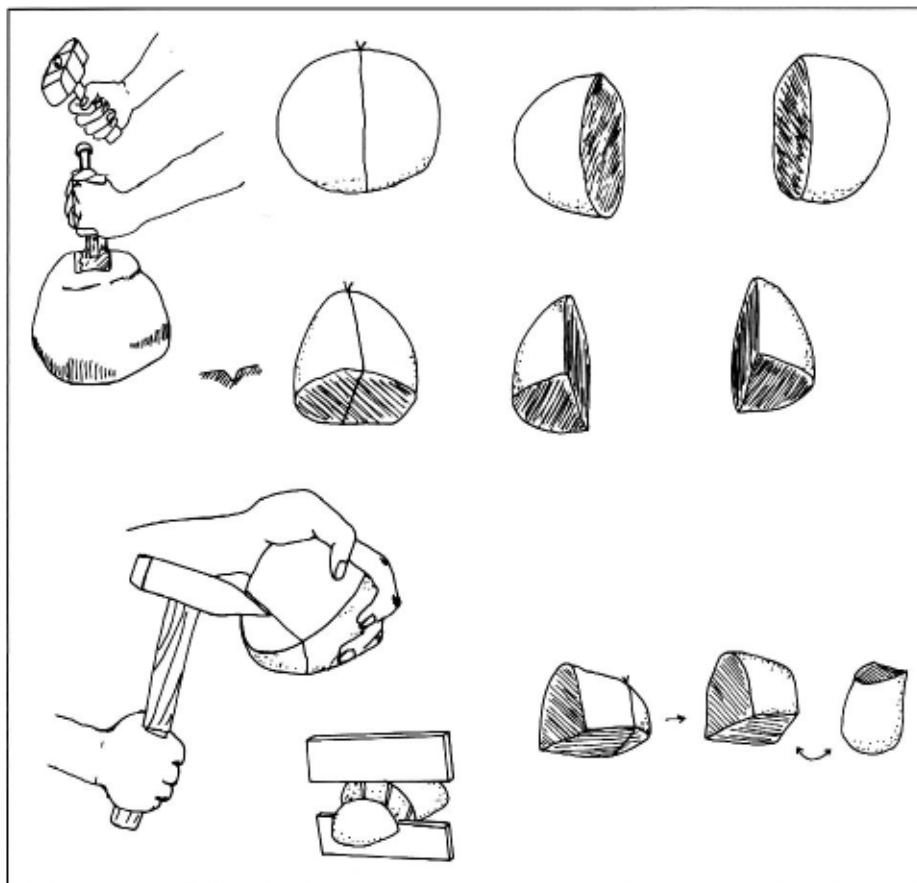


Figure 2: "Scabbling smaller boulders"

and various other constructions. These types of deposits are formed and sorted by natural transportation. Strong and stable stones have survived a rolling action during millions of years.

Formation of Deposits

Their formation by water or glacial transportation and abrasion, grinding and breaking tends to depend on schistosity, stratification and weaknesses due to differences in texture while shape-sorting creates spherical, ellipsoidal, and disc-shapes with various degrees of rounding.

Collection

To gather material from sources *in situ* is easier than from accumulations - be it road or riverbed cuttings. The stones are in a stratified graded position, horizontal, inclined or unstratified.

Siliceous stones, as for example quartzite, are most resistant to abrasion during the transportation process, whereas the survival of granites are variable. All strongly micaceous rocks, sandstones and limestones are easily abraded. Other varieties like phyllites or slates hardly survive fluvial or glacial transport and less so when subjected to torrents, waves and currents of stormy coasts.

Cobbles are generally better rounded than boulders. Because they have travelled longer, they provide a resistant, hard and tough construction material, and are most commonly used.

Sorting and grading

When found as gravel beds or terraces, selective excavation and screening by a sieve in the field supplies the required sizes. Softer rocks, preserved when the terraces were formed, are to be rejected. These are weakened by constant humidity and other weathering influences, resulting in the loss of cohesive properties, or the minerals are altered by active chemical and bacterial reactions from acid or humic soil.

Deposits in the above mentioned places are categorized as boulders, cobbles or float, disregarding size or shape, and contain a wide range of rocktypes. Unconsolidated rock is also found in disused quarry and mine wasteheaps.

Sorting and grading is a prerequisite. Sizes are based on the largest dimensions of 10, 20 and 30 cms and subdivided according to shape. The largest faces are reserved for cladding. Rectangular shaped stones form the most important pile. The second pile should contain larger and flatter stones for bonding and so on.

Extraction of Boulders for Slabs

In Africa and Latinamerica ornamental granite stones for walls are extracted from large boulders, normally round-shaped or tabular, round or smooth-edged, as they are easier to manipulate. Prospection for boulders does not vary from any other exploration: Colour and uniformity are observed by removing one or more industrial sized blocks, and their physical and ornamental properties are checked. After selection, the stages of extraction are:

- clearing
- hole demarcation and drilling
- broaching
- blasting
- squaring, scabbling and transportation to the building site.

Exploitation of boulders is attractive as it requires a minimum of cutting to obtain well squared blocks. The area has to be cleaned for appropriate working conditions and the drill hole(s) marked, usually on top of the boulder, for drilling with a jackhammer.

Procedure

The vegetation, soil and other float around the boulder is cleared for a clean break and for avoiding "sticking" and irregular cuts, when blasting. The isolated boulder, free on all sides, is drilled, after carefully fixing the place and direction of the hole(s). The best cutting plane is the direction of the orientation of the rock's minerals.

Hole(s), parallel to the best cutting plane are drilled manually by bar or with small jack hammers. Black gun powder, often mixed at the site, is then inserted. In manual drilling penetration is forced by blows with a 10 kg sledge hammer on a bar of one inch diameter, rotated to assist the perforation and lubricated with water. A 2 m deep hole is needed for a 5 meter tall boulder or a depth equal to 70%. With a jackhammer a hole takes 5 minutes to drill a 2 m hole and (manually) 4 to 5 hours to complete. A "broaching tool" is needed to make two small grooves perpendicular to the stone face with the holes, to direct the splitting.

The black gun powder is inserted about 10 cm for each two meters of a hole with the fuse in the gun powder up to the top of the hole. The remaining hollow is filled with stamped earth. After the blast, the parts of the boulder will fall down. Squaring then gives the boulder a rectangular shape. When cutting into slabs by

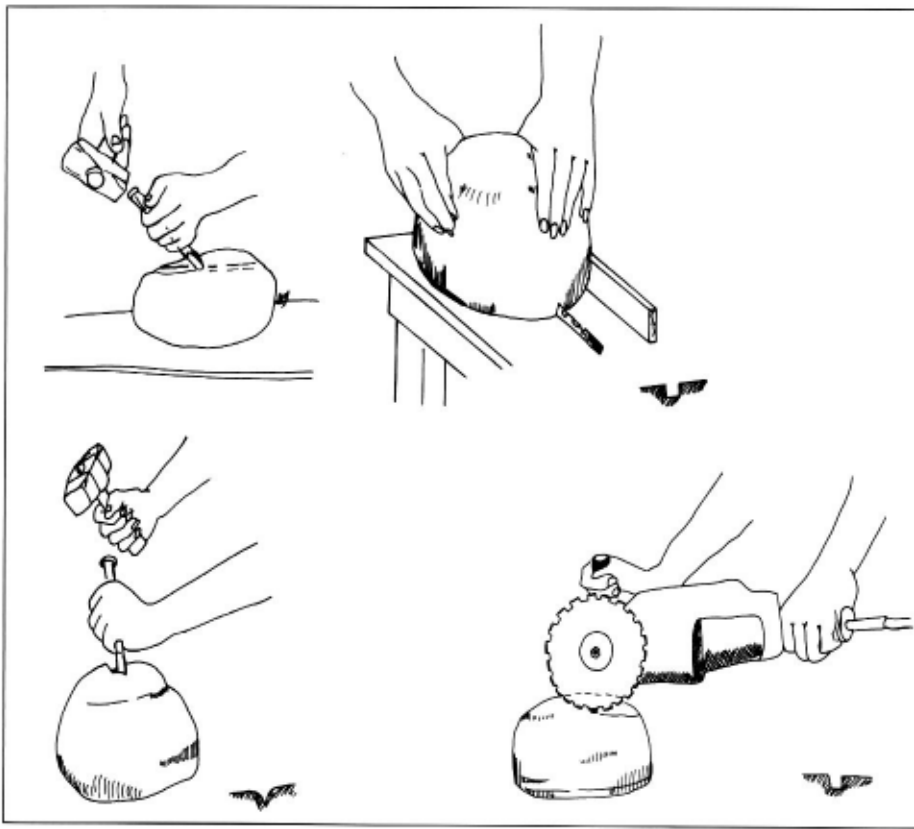


Figure 3: "Cutting and dressing smaller boulders"

gangsaw is intended, the ideal sizes are 3,0 m in length, 30 cm in height and 1,05 m in width. For slicing by handtools, the optimal natural sizes are adhered to.

Scabbling with two kilos sledge hammers and point chisels takes off any projections on the block sides to provide smooth rectangular shapes.

Dressing, Trimming and Breaking

Cobbles can be used as-is or converted into ashlar; occasionally elongated boulders are used as sills or lintels. Being ro-

unded or with prominently curved profiles, special cutting techniques - unlike when dressing building stones from consolidated sources - are used as shown in Fig. 2 & 3. When spherical, trimming or splitting provide flattish faces and arrises. Those boulders with flattened profiles are the most practical to use and can be trimmed with a guillotine with parallel blades - the upper one pivoted to allow a small angle (see Fig. 4 & 5). Shallow grooves, usually cut with one pass, allow clean breaks on uneven surfaces. Large quantities of stones are cut by hydraulically

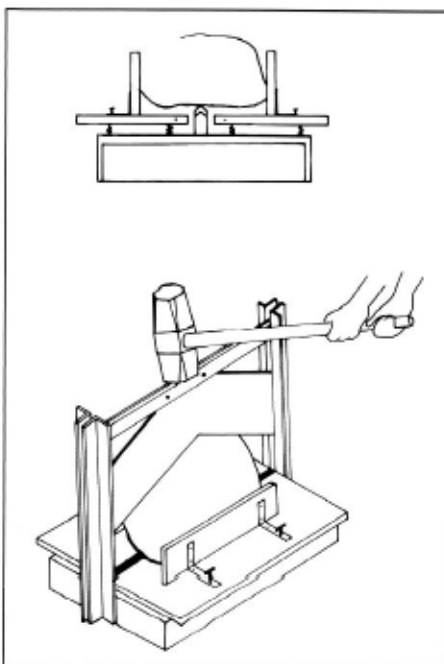


Figure 4: "Cutting techniques"

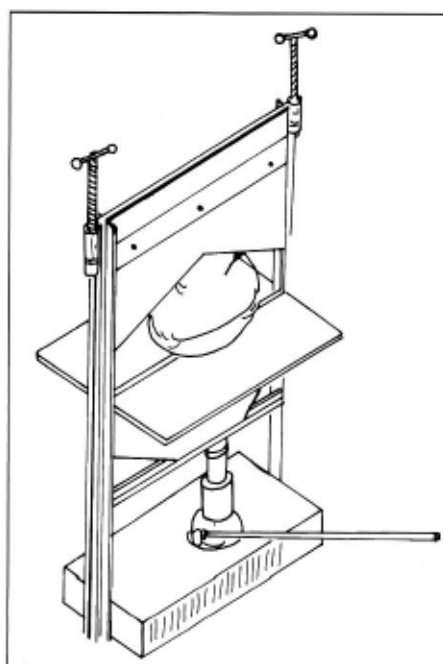


Figure 5: "Guillotine trimming with hydraulically operated blades."

operated blades.

In their natural shape they can be used for dry or mortared walls. The quality of any built structure is governed by the way the stones are stacked. Often, the only tools required for dressing are hammers for trimming or sizing cobbles to shape or the desired size. Boulder deposits are often used for building rubble walls and random courses.

Boulders for Foundations

The skill in using cobbles for walls or footings comes with practice in matching and grading and is, in addition, assisted by gravity: the cobbles are rather dropped than "placed" or tamped into position, when building a wall or footing.

For the foundations a trench is dug in the shape of the house, tamped and then filled-in by systematically throwing in boulders and cobbles, possibly topped with a reinforced concrete belt. Strength is increased by selecting and stacking the stone with a minimum of concrete or mortar and by applying the principles of dry-wall construction (Figure 6). A slight inward angle of the stones toward the centre causes the outer walls of the structure to lean against each other, thus increasing stability. Open spaces can be filled with small stones and provide a good drainage, especially for below ground level work. The depth of the foundation seating depends on a resistant soil or rock. The base of the trench, the weight of the structure, and environmental factors, determine the need for concrete. For a compacted base of clayey soil, or clay, with or without stone, a footing course is sufficient for one to two-storey buildings. The footing top which should be levelled with a concrete belt of about 30 cms thickness, especially in earthquake prone areas, takes the lowest stone course.

Boulders for Wall Building

The more traditional use of boulders or cobble stones is for retaining walls to keep back earth, soil, infill, and terracing, or to preserve contour levels, road cuttings, or control erosion, with one face exposed. Such a wall usually does not exceed 1 m in height if built dry with a thickness of about 45-50 cms.

In free-standing walls with both faces exposed, the difference in construction with ashlar or slabby building stones depends on the dressing and shaping technologies as mentioned before. Stones with vertical faces on the outside, set at fairly regular intervals, form the pattern of the wall and fix the courses. Timber uprights as used in



Figure 6: "Dry-wall construction with squared granite boulders in Argentina"

"Spanish Walls" are filled with cobbles and mortared during setting or after completion. Big stones for the footing prevent setting problems which occur when larger stones rest on smaller stones, especially of irregular forms as in random rubble, which are "coursed-in" with quoin stones (ref. Technical Brief on „Slabby Stone Deposits...“).

Glossary

- quartzite: metamorphosed sedimentary rock composed almost entirely of quartz grains
- cobble: stone naturally rounded by erosion
- footing: stepped courses of masonry in foundation
- scabbling: roughly faced with pick or hammer
- quoin stone: external corner stone.

Bibliography

- "Practical Stone Masonry" (P.R. Hill et al, 1995, Donhead Publishing, London, U.K.)

- "The Development Potential of Dimension Stone" (A. Shadmon, 1976, United Nations, New York - ST/EAS/34, U.S.A.)
- "Stone – an Introduction" (A. Shadmon, 1996, IT-Publications, London, U.K.)
- "Modern Practical Masonry" (E. Warland, 1953, Pitman Books, London, reprint by Stone Federation, London, U.K.)

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Published by **gate**

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(1997)

What is BASIN?

Building materials and construction technologies that are appropriate for developing countries, particularly in the low-income sector, are being developed, applied and documented in many parts of the world. This is an important prerequisite for providing safe, decent and affordable buildings for an ever-growing population.

But such new developments can do little to improve the building situation, as long as the information does not reach potential builders. The types and sources of information on standard and innovative building technologies are numerous and very diverse, making access to them difficult.

Thus, in order to remedy this drawback, Shelter Forum, GATE, ITDG, SKAT and CRATerre are co-operating in the Building Advisory Service and Information Network, which covers five principal subject areas and co-ordinates the documentation, evaluation and dissemination of information.

All five groups have a co-ordinated database from which information is available on Documents, Technologies, Equipment, Institutions, Consultants as well as on Projects and Programmes. In addition, printed material or individual advice on certain special subjects is provided on request. Research projects, training programmes and other field work can be implemented in co-operation with local organizations, if a distinct need can be identified and the circumstances permit.

BASIN is a service available to all institutions and individuals concerned with housing, building and planning in developing countries, but can only function efficiently if there is a regular feedback. Therefore, any publications, information, personal experiences, etc. that can be made available to BASIN are always welcome and will help BASIN to help others.



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