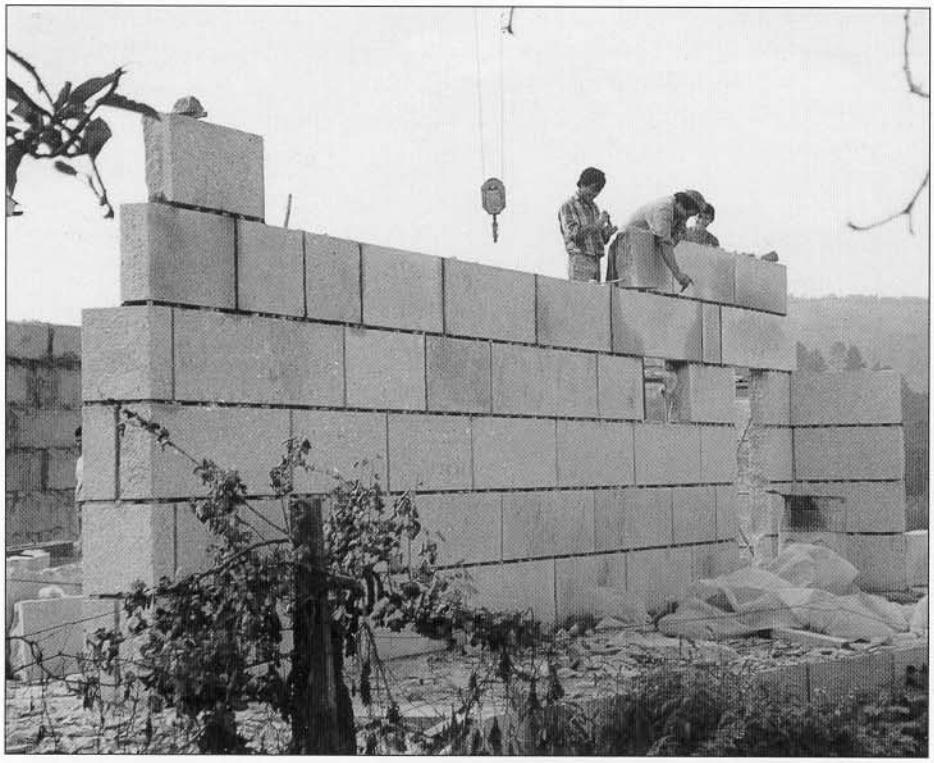

Figure 5: Stone house in Alpindurada near Oporto, Portugal

part a certain amount of pliability. Such devices (with exception of quoins) include corner ties, jambs or piers made of cut stone, hard-stone cupola ties, and iron or wooden ties which bind the corners of a building. Floors act as braces or stays in a structure; as do partition walls, corner returns and wall heads (butresses). Some details like this, e.g. window or door openings are shown in Figure 5.

Production of Building Stones

Shapes used for building stones are a matter of expedience and preference.The various ashlar and rockface patterns require basically similar extraction techniques.

Stone shapes, textures and construction patterns can be combined in many different wall types. Whereas the needs of individual builders may be supplied from small ledge quarries and existing waste heaps, any larger buildings, such as schools, etc. require an extraction of the stones from geologically planned quarries.

Extraction

Stones from insitu rock are removed with appropriate extraction tools such as saws, drills, hammers, chisels for breaking and cutting, as well as levers, jacks etc. which are primarily used for loosening the stones. Exploitation of unconsolidated stone involves collection of the stones by lifting, manual grading and moving the stones with various devices including stone sleighs, wheeled carts and self-propelling earthmoving equipment. For larger stones, other types of lifting equipment can be used with planks, beams, ropes and/ or cables.

Removal from the quarry face can be done with levers, bars or specially designed or adapted handtools hand-drills, jackhammers and mechanical jacks, which are used for cutting, chanelling, wedging and other treatments, depending on the nature of the deposit, production and use requirements.

The simplest way is to prise a bed with a lever, or where joints are wide enough, to force the rock apart with jacks. Where available, a shoveldozer should be used to prise rocks loose. In other cases wedges or plugs are used. Shallow furrows or grooves can be drilled or cut into the rock for insertion of the wedges. The drilling can be done with pointed bars or plug drill and hammers, jackhammers or electrical drills where a generator or a power grid is available. More recently, self-propelling mechanical chisels e.g. of the Bobcat type, are used to subdivide rock bedding.

Stone saws are available from small 5 HP models with 60 to 200 cms sawing discs which can cut dimension stones in the quarry. Depending on the hardness of the stone, tungsten carbide or diamond segments are used. Except where the use of hand-tools is preferable (e.g. when working with near horizontal and well developed slabby beds) the compressed air jackhammer is still the most versatile extraction equipment.

Stone breaking and dressing

Stone breaking requires suitable support from benches, floors, sand-boxes, plants, pipes or angle iron. Whereas in extraction, the bar or lever is the most versatile tool used for prising, lifting, breaking, drilling and even testing, for breaking the stone a hammer is preferred.

Hammers may be chisel-pointed at one end or can be used in conjunction with chisels. The ability to strike with a minimum effort is a combination of hammer

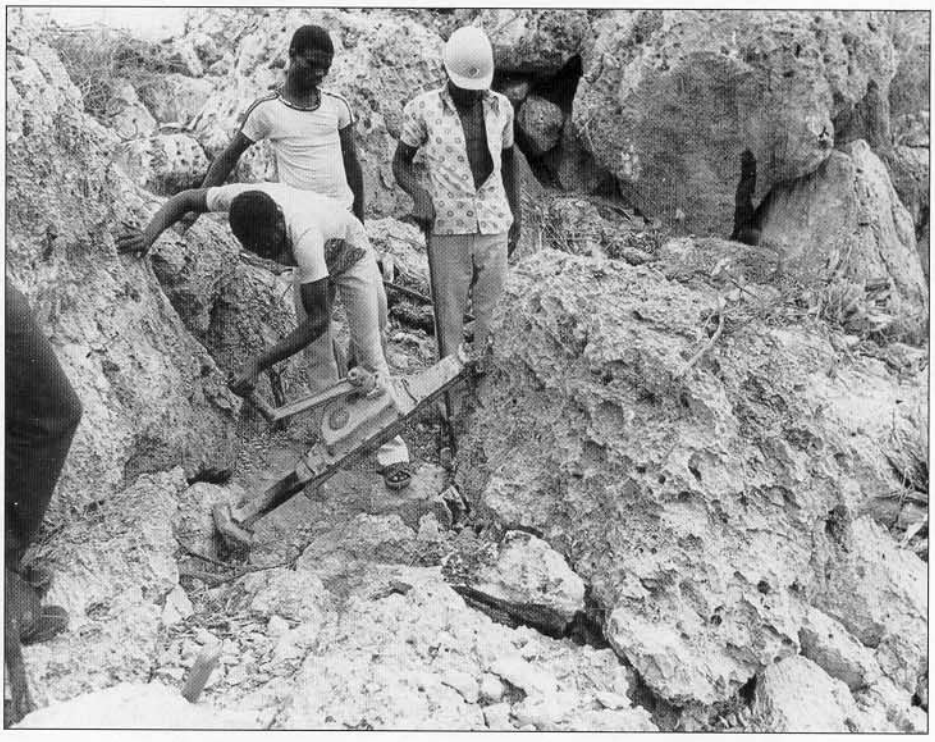

Figure 6: Prising rocks loose by mechanical jack in Morne La Pierre, Gonaives, Haiti

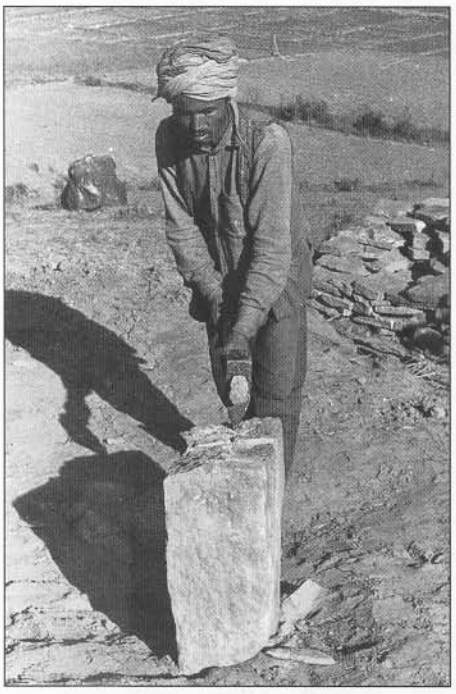

Figure 7: Breaking stone in Surketh, Western Nepal

weight and shape, handle length and the holding, swinging and stance of the worker. With a hammer of approximately 5 kgs weight a stone mason can break a rock mass of many tonnes.
Equally important is the natural breaking direction. The aptitude of the mason's ability as to where to hit the stone makes the difference between a fragmented result and fairly straight cuts and regular shapes. The working position for the actual finishing of stone pieces differ in various parts of the world; some masons work in a sitting or squatting position, the stone is layed flat on the ground or supported at an angle.

Apart from the hammer, the chisel is also a very good tool for shaping and dressing stone surfaces. Tungsten carbide tips save grinding time and are also used with compressed air tools.

Saws, both hand and power operated, subdivide soft stone blocks. Hard varieties require wedging devices and guillotines for breaking. Dry cutting diamond disc power tools find increasing use for on the site trimming of building stones and are useful to cut grooves for wedging, instead of the laborious groovings by hammer and chisel or pick; their use is especially important for modular building stone units and components which require a tight fit or where channel or V-jointings are wanted.
Handoperated guillotines are particularly efficient for the production of building stones from thick slabs of widths between 15 and 70 cms, and thicknesses between 7 and 30 cms; larger pressures up to several hundreds of tonnes can tackle larger dimensions and meet the needs of big construction projects.

Masonry practices

Typical stone types for walls include: ashlar (uncoursed and brought to courses), squared rubble (which can be uncoursed), snecked rubble (brought to courses), polygonal rubble (mainly from quarry waste). Cornerstones from these stone types (quoins) are usually squared to provide a loadbearing framework and neat appearance.

Laying the lowest course of the wall needs particular care. Besides ashlar and rubble, slabby stone (flagstone) and components make up the four principal stone types for walls. Natural slabby stone are used in thin layers for face walls, fences and for the construction of pavements and floors. Components are cut stone, other than ashlar and are used for lintels, sills, caps and similar masonry units. The thickest and heaviest rocks should be kept for the lower courses to avoid unnecessary lifting. When laying a wall, the following should be considered:
The best flat face of the narrow dimension of each stone should face outward and be bedded solidly on the stones below. Uneven surfaces of stones (which make the stone "wobble") should be chipped

Figure 8: House in Alpindurada near Oporto, Portugal

and dressed straight rather than shimming the wall with small stone pieces and wedges which tend to work loose in time on the outer faces. In massive walls the principle of two-over-one and one-over-two prevents lines of weaknesses appearing in the wall.

Joints must never have a vertical "run" through the wall. In cases where not sufficient bond is provided, the wall could "fold-up", as dynamic stresses concentrate at the weakest point. Every 2 to 3 meters a long tie stone helps in tying one face to another. Rectangular stones of even thickness, the longer the better, should be reserved for wall ends and corners, especially for external walls. The higher a wall, the wider and deeper the footings should be. The importance of "bed-laying" of building stone cannot be overemphasized.

Mortar

The amount of mortar (preferably a mortar on a lime base) for filling the joints or for putting up the walls partly dry, depends on the type of stone available, its use and size of structure required. The stone is usually stronger and more durable than the mortar in which it is bedded. Well tied, stacked and bonded stonework without mortar is more stable. In some cases it is also more attractive than an indifferently built wall with thick mortar joints. However, walls have to be less massive with a mortar bond. Mortar seals the joints between the stones and enables the use of different shapes and sizes. It also facilitates the use of surface rendering.

Cement (or hard) mortars are more vulnerable to strains in the walls. Mortar for stonework walls should be less wet than mortars used for clay brick and/or concrete block walls. One reason for this is to prevent dribbles and rims on the finished wall. Raised joints (pointing) for stone walls are to be discouraged. They serve no useful purpose.

Conclusion

In general it can be observed that dimension stone production with low initial capital investment, labour-intensive inputs, low-grade skills, negligible energy inputs imply low production costs. The low value-to-weight ratio makes distribution a critical factor. It is very important to consider proper planning of any construction site near stone sources. Small-scale artisan units and stone masons' workshops should be located near intended markets.

Reliable quarries require a geological investigation for optimal supplies. In an integrated stone development project building stones are produced from blocks too small for marble production. A geological survey of stone sources should be conducted within a radius of approximately 10 kms from the processing site and/ or building site. Such a survey normally also provides the necessary information on the volume of available reserves.

Glossary

- phyllite: a clayey rock intermediate in metamorphic grade between slate and schist
- schist: a foliated metamorphic rock which splits easily
- marl: a calcerous clay
- karst: uneven morphology due to enlargement of joints by water action
- rubble: walling stone of irregular shape and sizes
- ashlar: finely squared stone to given sizes
- snecked wall: squared rubble wall uncoursed, built to a regular pattern consisting of one riser, two levellers and one sneck (a small roughly squared stone used in snecking).

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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.

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