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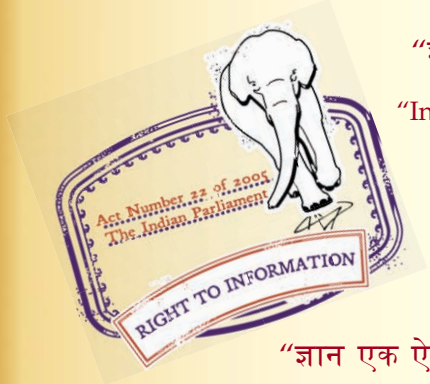

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RECOMMENDED PRACTICE FOR QUARRYING STONES FOR CONSTRUCTION PURPOSES

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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Indian Standard

RECOMMENDED PRACTICE FOR QUARRYING STONES FOR CONSTRUCTION PURPOSES

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Indian Standard

RECOMMENDED PRACTICE FOR QUARRYING STONES FOR CONSTRUCTION PURPOSES

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 17 February 1977, after the draft finalized by the Stones Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 A number of stone quarries exist in this country and to quarry stones for construction purposes from such quarries certain methods based on past experience are followed. This standard, which is in the form of a guide, has been prepared based on the practices being followed by the Mining and Geology Departments of various states of this country which have a good number of quarries. This guide will be therefore useful for those departments which intend to start quarrying in the new mines.

0.2.1 All quarrying work will, however, be done according to the statutory rules in force, and wherever there is any conflict the requirements given in statutory rules shall prevail.

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1. SCOPE

1.1 This standard covers the recommended practice for quarrying of stones for construction purposes.

2. GENERAL

2.1 Stones for construction purposes can broadly be classified into following classes mainly on the basis of its use:

a) Dimension stone,
b) Irregular stone, and
c) Crushed/broken/natural stone.

2.1.1 The term 'dimension stone' is applied to blocks or slabs of natural stone and can be cut into definite shapes and sizes; irregular large size blocks 'rubble' obtained by breaking are used in the spillway construction of dams, bridge construction having specific requirements while crushed and broken stones include irregular fragments that result from crushing fine rock powder produced by various grinding processes and natural stones are boulder stones, gravel and sand available in river beds.

2.2 The quarrying of the dimension stone is required to be done with utmost care to avoid shattering or damaging the block in any way. It also requires a careful selection of quarry site in order to maintain uniform texture and colour and also freedom from cracks, flaw, etc. On the other hand, the quarrying of crushed and broken stone is designed to break the rock into fragments with heavy charges of explosives, its reduction into smaller sizes by impact or rolls and its screening, etc. The common aspect in these two branches is with regard to the production of the crushed and broken stone while mining and processing the dimension stone and less commonly, the production of the blocks when quarrying the crushed stone.

2.3 For quarrying operation of any dimension stone, intimate knowledge of the geology of rock formation is a primary and practical necessity. One of the important geological features which control the economic working of stones is the structure which includes strike and dip, folding, faulting, joint pattern, imperfection of the occurrence, etc.

2.4 Common dimension stones include, marble, granite, limestone, sandstone, charnnockite, trap, etc.

3. MARBLE

3.1 Selection of Quarry Site — Quarrying of marble requires the cutting of the blocks of as big size as possible and free from cracks or flaws. One has to be very cautious while undertaking marble quarrying operation because in that it is an absolute necessity that integrity of the block is fully preserved. An unsound block with cracks is of no use. The quality of the marble may be fairly constant through a given bed, but an adjoining bed even though very near may have different quality. It is, therefore, necessary that to have high quality and uniformity of the product, the beds may be followed closely. There may be reoccurrences of beds reappearing at the surface due to folding and faulting. Dip of the deposit also governs the quarrying of the marble. Marble bed of low to moderate dip is comparatively easier, safer and economic to work.

3.1.1 Bedding planes as well as jointing system plays very vital role in the quarrying of this monomineral rock. Wide spacing of the joints greatly increases the value of the deposit because in that case the blocks of bigger size can be excavated which fetch high prices. Some joints are open and conspicuous while others are so obscure that they are difficult to recognize. The cuts are so placed that they intersect the joints of the blocks as little as possible. Blocks interesected by oblique joints are virtually useless. Besides the joints, there are major and minor cracks, more so near the surface. Majority of the cracks disappear at some depth. Trained eyes are, therefore, necessary to examine such geologically vital aspects.

3.2 Quarrying Method — After studying the geological feature of a particular deposit, method of quarrying is decided. Quarrying of the marble includes removal of the overburden, opening of free faces, delineation of the marble block and excavation of the block. So far underground mining for marble is not adopted in our country.

3.3 Removal of Overburden — First of all overburden is removed which may be done manually. Blasting may be resorted to where hard strata occur. Drilling of the holes may be done either by manual labour or by compressed air drill. The waste rock may be transported to sufficient distance away where there may not be any mineral occurrence or a marble bed of good quality underneath.

3.4 Opening Free Faces — Removal of the overburden exposes joints and planes of weaknesses at the top of the deposit which are examined minutely. Thereafter one free face is opened along the strike of the deposit while another free face is excavated across the strike. The channels of the free faces are cut by blasting holes of about 2·5 cm dia and about 0·5 to 0·7 m in depth. At a time, only limited number of holes are blasted which are under charged so that no damage may be caused to the block by development of cracks due to blasting. The drilling of the holes for excavation of channels may be carried out either manually or with compressed air drill. The cutting of these channels is a major time consuming operation which takes quite a long time. The width of these channels is approximately 0·6 to 0·8 m. The depth of the channels may be from 3 to 6 m depending upon the availability of natural joint in depth. The length of these channels are decided upon by the distance between the joints across as well as along the strike. These joints thus delineate the block which is under extraction.

3.5 Loosening the Block — After opening these free faces, a single hole of about 4 to 5 cm in diameter is drilled roughly at a point where the joint perpendicular to the strike channel meets the joint perpendicular to the channel across the strike. The approximate location of this hole is shown in Fig. 1. The depth of this hole is about 30 to 35 cm less than the depth of the channel, so that effect of blasting may not be passed on to the block underneath. The hole is under charged with gun powder and blasted which causes the loosening of the block.

3.6 Separation at Bottom — The block at the bottom can be separated by drilling the holes along the line determined by the thickness of the block desired, putting in the wedges and then hammering them in succession. A series of holes may be drilled with spacing of about 5 to 10 cm. These holes may be drilled either manually or by compressed air drills. After drilling holes wedges of about 15 to 20 cm in length are driven in and hammered lightly first followed by subsequently hard hammering so as to cause the separation of block from the bottom.

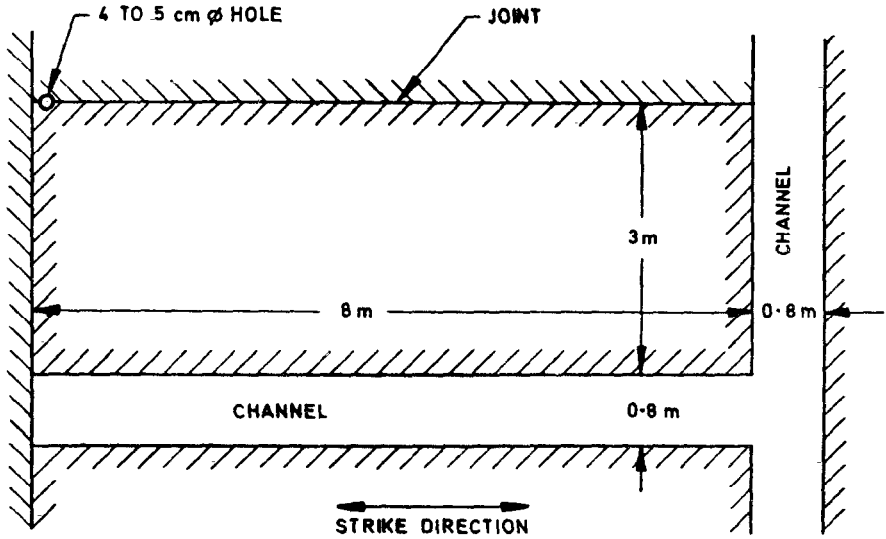

FIG. 1 LOCATION OF HOLES FOR BLASTING IN MARBLE QUARRY

3.7 Subdivision of Block — The big block of the marble so cut is further subdivided to obtain smaller blocks of the desired size. The procedure for extracting the smaller block also involves the drilling of the holes (which may be drilled in the direction of 'rift' or 'grain' or marble thus taking advantage of ease of splitting) and then putting in the wedges and hammering them as described above.

3.7.1 The block so obtained are subsequently dressed by chisels and hammers so as to make it perfectly rectangular. Thereafter the blocks are lifted and loaded in the trucks or bullock carts by means of manually operated or machanical crane and transported to the factory for further processing.

3.8 Quarrying Operations — In this way quarrying of the marble blocks progresses in depth as well as in the lateral direction by formation of benches in systematic way. As quarrying operations proceed in depth, the delineation of the blocks become easier in comparison to the extension of working in lateral direction. This is because of the fact that in depth there is almost disappearance of cracks and joints are prominently visible. Downward extension is also favoured because in that case marble obtained is of better quality and free from the cracks and flaws, etc.

3.9 Wire Saw Method of Quarrying — Mechanized method of marble quarrying provides the adoption of the wire saw method which consist of the 1 or 3 strand ropes of 10 mm diameter which runs as a belt and cuts by abrasion when fed with sand and water.

4. GRANITE

4.1 Selection of Quarry Site — Granite occurs widely in many states of the country. However, relatively quite a few of the occurrences have the qualities, locations or working conditions requisite for adaptability to industrial use as dimension stone. The selection of suitable quarrying area is of paramount importance. The out-crops should be examined very carefully. Examination of rock during or immediately after rains is useful because hairlines, streaks and knots, etc, are better recognized under wet conditions. Area chosen for mining should include masses of rock of even grained uniform texture, attractive colour and relative freedom from irregular or closely spaced seams and from dykes, knots and hairlines. These requirements are rigid in the case of stone used as monumental or architectural polished stone. However, a liberal variation is permissible in the stone when used for paving blocks, curbing and unpolished building stone.

4.1.1 Granite hills are very common and in abundance in granite area. Most of the granite masses are intersected by cracks and joints. The most favourable condition is one in which the joints are spaced several metre apart and are in two parallel system approximately at right angle to each other. If the joints are irregular and closely spaced, then adequate size of blocks may be unobtainable. Wide spacing of joints is necessary in case of slabs or big blocks but where '*KHANDAS*' are required this is not necessary.

4.2 Making Primary Cuts — The primary cuts will separate the block from the parent mass. For this purpose full advantages of joint system should be taken. If such natural planes are not available then cut or fracture may be made by discharging gun powder in drill holes which should be just enough to cause fracture without causing the shattering effect.

4.2.1 Primary cuts may be made by drilling and broaching method. The broaching method consists of drilling of closely spaced deep holes in straight lines and thereafter web between them may be removed with a drill or a flat broaching tool substituted for drills. In this way a narrow continuous channel is made.

4.2.2 A substitute for drilling and broaching method is jet piercing method. Combustion of oxygen with fuel oil generates temperature to the tune of about 2 760°C and so when water stream joins the flames, it disintegrates rock into fragments. This method is very fast in comparison to drilling method.

4.2.3 Use of wire saw equipment is the latest method for making primary cuts. This equipment consists of three strand or single strand wire that runs as belt under tension and when fed with cutting agent like granular aluminium oxide along with stream of water, it cuts a narrow channel by abrasion.

4.4 Floor Breaking — After a primary cut is made the next step is to separate the block from the bottom. For this purpose natural horizontal parting planes are of great assistance but in their absence or under the circumstances of wide spacing floor breaks may be made by driving wedges in horizontal drill holes at the base of block. In this way a large block may be separated from the parent mass.

4.5 Subdivision of Block — The next step is to subdivide the block into the convenient sizes and shapes. In this process natural splitting directions of the rock should be taken into account. Usually two directions for easy splitting are available which are at right angle to one another. Out of these two directions, one direction is more pronounced for easy splitting which is known as 'rift' while other is called as 'run' or 'grain'. For obtaining splitting easily and for getting smooth surfaces, the major fractures are made in the direction of rift or grain. However, in granite these may not always be pronounced. The holes of about 10 cm depth and several centimetres apart are drilled along a line where break is desired. The break is made by driving plug and feather' wedges in the hole. The feather consists of two iron strips flat on one side for contact with wedge and curved on the other to fit the wall of drill hole. They are placed in the hole and the plug (a steel wedge) is placed between them. They are sledged lightly in succession until a fracture appears. Thus block is sub-divided in the smaller desired sizes which are transported to processing mill where processing is carried out.

5. TRAP

5.1 Selection of Quarry Site — Trap is amply used as building stone under the trade name 'black stone'. For selecting quarry, outcrops should be examined carefully. The rock is usually characterized by two or more sets of joints. Irregular joints are also common. It is also characterized by flow structure. Flows of different varieties, such as massive, amygdaloidal and porphyrite are common. The weathering in trap area is generally more.

5.2 To establish the quarry in trap rock, it is essential to remove the overburden and weathered zone present at the top. Then a face is developed for better quarry operation. Hole may be drilled to ascertain depth and weathering and fresh rock from the surface. For obtaining big size blocks in trap, it is advisable to do the blasting with moderate charge as the rock is characterized by the presence of block

joints. These blocks are commonly used as rubble and face stones in the construction of masonry dams, bridge piers, etc. Similar fragments which remain at quarry are utilized in rock works as chips aggregates for pitching rip-rap, etc. Trap can be crushed or broken to small pieces of required size in order to obtain aggregates. Big blocks obtained from quarry can be made to size for using them as guard and boundary stones. This rock is not easily dressable due to its jointed nature.

6. LIMESTONE

6.1 Selection of Quarry Site — The requisite qualities which are essential for limestone to be used as dimension stone are its compactness, easy workability, uniformity in texture and attractive colour. Deposits with irregular or closely spaced joints are unsuitable because large blocks free from cracks or line of weakness are demanded. A deposit should be capable of furnishing rectangular blocks few metres in length and width with suitable thickness and free from cracks.

6.2 Overburden Removal — The quarrying of limestone is comparatively easier because usually the deposits are approximately flat inclined with moderate thickness. As usual the first step in quarrying is the removal of non-commercial rock. Planning should be done so as to preserve important areas and accordingly waste may be dumped at suitable distance by power shovels, dumpers or other earth moving equipments.

6.3 Primary Cuts — Next step is with regard to making the primary cuts. In smaller quarries with relative thin limestone beds, the primary breaks may be obtained by blasting gun powder in drill holes. Subsequent break may be obtained by wedging action, however, at times light blasting may also be needed. In large quarries the primary cut may be done with a channeling machine which operates with choping action similar to that of a reciprocating drill and cuts a channel or narrow trench of about 5 cm or so.

6.4 A Porbander Stone — A miliolite limestone is amenable to cutting by an axe, and blocks of size 35 × 55 × 20 cm are common.

6.5 Bed Lifting — Bed lifting or the separation of the block from the bottom is done by drilling the holes and subsequentiy use of wedges. A series of holes are drilled in which wedges are driven in and hammered in succession until a flour break is made. In this way a big block of the limestone is separated from the parent mass.

6.6 Block Subdivision — Subdivision of the block into desired sizes is made by drilling and then using wedges as described above. These are hoisted and transported to stacking yard.

6.7 Scabbling — The blocks may be scabbled at the yard or at quarry site. Scabbling is the process of trimming the block to uniform rectangular shape. Scabbling picks or chisels and hammers are commonly used to remove all irregularities.

7. SAND STONE

7.1 The quarrying of sandstone is similar to that of limestone. Natural joints usually in two or more systems characterize most sand stone deposits.

7.2 For undertaking quarrying operations, overburden is removed first, subsequently primary cuts are made, block is lifted from bottom and then subdivided by drilling and wedging actions. While blasting care is to be taken that just enough gun-powder is used to develop a fracture only. The various steps of quarrying are almost similar to that as described for limestone.

8. CRUSHED/BROKEN/NATURAL STONE

8.0 Several types of stones are used for this purpose. The principal varieties of stones used for production of crushed and broken stone are limestone, granite sandstone, gneiss, quartzite, trap, etc.

8.1 Quarrying — Quarries are either located in hills or on ground. Usually the crushed and broken stone is mined by open pit method. If beds are flat lying and relatively thin, the pit should be enlarged laterally while in thick beds, deeper and narrower quarries may be developed which involve less extensive stripping. If the beds dip at steep angles, the quarry may be worked to considerable depth but removal of waste rock to avoid a dangerous overhang involves increasing expenses as the quarry is deepened. Sometimes dewatering problems too are involved. In case of boulders, gravel and sand available in the river bed, the water current if any is directed and also ring bands if required are constructed, the quarrying is done up to a limited depth as permitted.

8.2 The quarrying and processing operations consists of removal of inferior rock from the surface of a deposit, drilling the holes, blasting the rock with heavy charge of explosives, loading of broken stone, conveying the rock to crusher and sizing the crushed product with various types of stone. The quarrying and processing operations are also done by means of crowbars, hammers and wedges only where fissured rock or only big size boulders are available.

8.3 The weathered rock overburden may be removed by drilling holes, blasting the rock and using the shovels, bull dozers, etc. The holes may be drilled with compressed air hammer drills. The choice of explosives depends somewhat on the use to which the stone is to be put. High grade explosives may be used where extreme fragmentation is desired. In preparing stone for lime burning or in any crushed forms where fines are undesirable, explosives with a high rate of detonation are not used in it. Using the appropriate explosive, the stone is blasted loaded into trucks or loaders, and then transported to stacking yard.

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