

readily carried by air currents and do damage for a considerable distance from the source of pollution.

When these sulphur acids descend with the rain, snow or fog upon the calcium carbonate of ordinary limestones, calcium sulphate is formed and carbon dioxide is liberated. The rain washes away the sulphate, causing *erosion* (wearing away) of the surface of the stone. The action of these acids on magnesian limestones has a similar weathering effect, the small quantities of magnesium sulphate and calcium sulphate produced are dissolved by the water present and tend to form a surface skin when the water dries out. Such erosion occurs chiefly on those external walls of buildings which are exposed to the prevailing wind (which in this country is from the south-west) and the washing action of the rain. The defect is not serious when the erosion is very gradual and uniform, and is considered by some to be an advantage on account of the different texture of wall surfaces which results. This natural washing by rain is responsible for the attractive dark and light appearance of Portland stone and similar limestone buildings.

Serious decay occurs when the sulphur acids cause the formation of a hard layer or skin on the outer surface of limestone, which subsequently blisters and flakes off, the latter condition being known as *exfoliation*. Such layers consist chiefly of salts (calcium sulphite and calcium sulphate). When the skin scales off, a fresh surface is exposed and a new hard layer is formed. Constant repetition of this process results in a weakening of the wall, and the appearance is, of course, very ugly. The decay only occurs on the surfaces of external walls which are sheltered from the washing action of rain; exposed surfaces are not affected, as the rain removes the salts and thus prevents the formation of the surface skin. Some limestones are less liable to this form of decay than others.

Soot is a product of combustion of coal and is largely responsible for the discoloration of stone. It may also cause decay. That from domestic fires especially consists of a large proportion of tarry matter and this causes the soot to adhere to stone surfaces. Sandstones are very liable to become discoloured, and in course of time most sandstone buildings in industrial towns become black and assume a drab appearance as the pores of the surface of the stone become filled with soot deposit. Limestone buildings are not so disfigured, except those sheltered walls which are not rain-washed and on which the soot is allowed to accumulate.

Decay of stonework can be retarded very effectively if soot and dirt are removed at sufficiently frequent intervals by either washing it or cleaning it by means of jets of steam.

Stonework is washed with water from a hose pipe (such as a fire hose) connected to the water main; a pumping machine is used if the pressure of the water is inadequate. Ladders, scaffolding or suspended cradles are required, as the stone must be scrubbed by hand with bristle brushes. An effective method for limestone buildings is to apply water in the form of a fine spray through nozzles to the stonework for one or two hours, and after a short interval the surface is lightly brushed with comparatively soft scrubbing brushes.

Steam cleaning is very effective when applied to walls which are much discoloured. The steam, generated by a boiler, is passed up a flexible tube from which it emerges on to the stone. A wire brush fitted on the nozzle of the tube is used to scrub the black surfaces,

The value of these processes in maintaining a clean appearance of buildings and arresting decay is being appreciated by an increasing number of property owners, and some buildings in towns where the atmosphere is highly polluted are washed yearly; other buildings only require such treatment every five or six years.

The practice which is sometimes adopted of using special cleaning preparations, such as caustic soda and other alkalis, is condemned, as such chemicals damage the stonework.

3. *Careless Selection*.—Stone obtained from soft beds in a quarry or mine will weather more quickly than that from the harder beds. A wall becomes unsightly if it consists of stones which do not weather uniformly. Careful selection should ensure that only the hardest and most durable stone is used.

4. *Association of Dissimilar Stones*.—Decay of sandstones may result if both limestones and sandstones are used together in a wall. Thus, for example, a limestone string course or limestone dressings to door and window openings in a wall mainly constructed of sandstone may be the cause of decay of the adjacent sandstone; plinths of sandstone have been known to decay because of the limestone above them.

The following is the reason for the decay: When salts, such as calcium sulphate, are formed (see preceding column), they may be washed from the limestone on to the surface of the sandstone. These salts may be absorbed and crystallize; as an increase in volume occurs when these crystals are formed, the resulting pressure just behind the surface disintegrates the stone; such decay may become extensive.

Similarly, when ordinary limestone is associated with magnesian limestone, decay of the former may occur due to the absorption of magnesium sulphate (see preceding column) from the magnesian limestone.

5. *Efflorescence* (see p. 13).—Decay may arise from unsuitable jointing material. The salts in cement and lime mortars may be absorbed by the stone; crystallization of the salts may occur and either set up decay of the stone (due to the resulting pressure) or cause efflorescence on the surface. Such defects are especially likely to occur if the jointing material is a rich impermeable cement mortar, for, in wet weather, water will be absorbed by the stone and not the mortar; as this water dries out from the stone surface only (and not from the joints), the salts are either brought to the outer face of the stone to cause efflorescence or they crystallize in the pores immediately behind it.

Brown or yellow staining of limestone walling may result from alkalis in the mortar. Discoloration of the limestone facing of compound walls may be caused from brickwork backing which is bedded and jointed with black mortar. It is desirable, therefore, that either suitable lime mortar (see p. 47, Vol. I) or asphalt be used to back the ashlar blocks, the latter being preferred, as the water-proof material effectively prevents the salts from the backing mortar penetrating the stone.

6. *Frost Action*.—This is described on p. 15 and is also referred to on p. 100. Porous and laminated stone is especially liable to decay caused during the winter by the absorption of water, which expands in the pore spaces and