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## COMMON DEFECTS AND THEIR CAUSES

An increasing number of defects on building facades have been reported in the last decade [2–12]. These include:

- cracking
- staining/discolouration
- sealant failures
- efflorescence
- rising dampness/water penetration
- corrosion
- buckling/deflection
- tile/plaster delamination

The common types of defects with respect to the various types of facades are shown in Table 1.

Among the common causes responsible for these defects are:

- a. Action of wind pressures underestimated at the design and construction stage. Cladding elements can be affected by short duration high speed gusting, local high wind pressure and suction effects.
- b. Insufficient knowledge on the construction/fixing of the cladding elements. Even if the suppliers of these fixing elements have already tested the elements to a certain standard, the actual use of such fixings may still need to be verified by additional tests appropriate to the particular situation.
- c. Insufficient knowledge on the durability of the fixings. The importance of design in affecting durability is often overlooked.
- d. Failure to carry out necessary maintenance or incorrect identification of the cause of defect resulting in more damage done.

**Table 1.** Common building facade defects in Singapore.

	Common Defects	Building Facades				
		Cement rendering	Tiles	Metal sheeting Al steel	Natural stone	Glass
1	Cracking	X	X	X	X	X
2	Staining/discolouration	X	X	X X	X	X
3	Sealant defects		X	X X	X	X
4	Efflorescence	X	X		X	
5	Rising damp/Water penetration	X	X		X	
6	Misalignment and chip off		X		X	
7	Corrosion			X X		
8	Delamination	X	X			
9	Surface appearance (a) Erosion due to rain water (b) Surface abrasion (c) Surface etching			X X X X		X
10	Physical appearance (a) Dentage (b) Deflection (c) Warping and buckling			X X X		

- e. Failure of joint sealants due to: (1) poor joint design; (2) inappropriate choice of sealant; (3) poor surface preparation and workmanship in installation of the sealant; (4) rapid thermal/moisture changes resulting in excessive differential movement; (5) ultraviolet radiation and high temperature and humidity.
- f. Inaccurate information from manufacturers resulting in misuse or inappropriate choice and use of materials.
- g. Designer lacks the knowledge of the physical properties, performance and potential deterioration of the materials.

The manifestation of defects on high-rise buildings have necessitated even more regular inspection and maintenance to be carried out on these buildings. However, the process of inspection and verification of defects on high-rise buildings is often hampered by many problems which discourage building owners from observing regular inspection and maintenance habits. These problems include:

- (a) Difficulties in testing and inspection.
- (b) Lack of understanding of testing results or significance of tests.
- (c) Lack of understanding of the behaviour of materials or the interaction between the different materials.

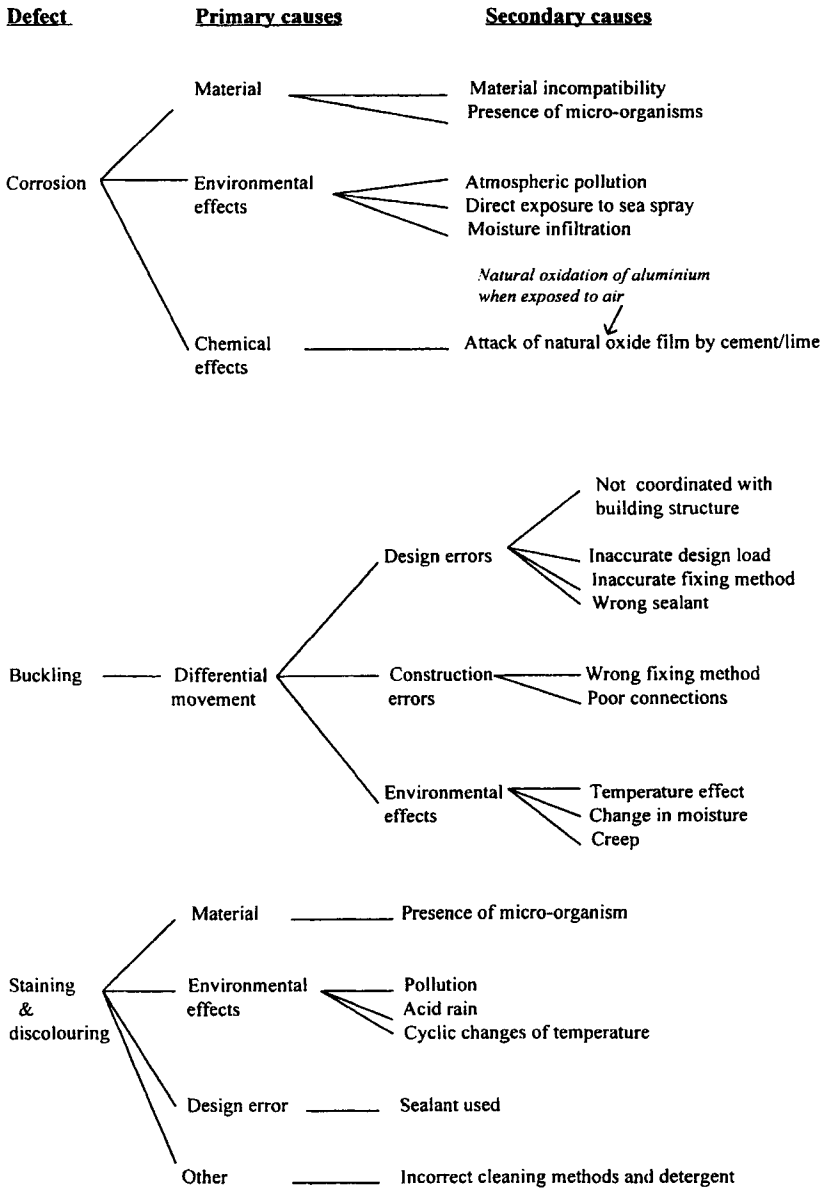
In some cases, inspection and maintenance works have been totally neglected by building owners. The existence of such problems have therefore resulted in a lack of long-term interest by building owners and maintenance personnel to carry out strategic planning for preventive maintenance on their buildings.

Figures 1, 2(a), 2(b) and 3 show the possible causes of each defect for three of the most common types of facade elements, i.e. aluminium, natural stone and glass.

In the case of metal cladding, the common defects observed include staining, corrosion, warping, erosion of coating and discolouration.

Deterioration of sealant is one of the primary causes of staining. Dirt accumulated at the sealant joints would also stain the facade during heavy downpour. The sparkle of the metallic surface would be lost if proper maintenance work is not carried out. The corrosion of anodised aluminium panel is characterised by the white powdery patches found at the joints.

### Aluminium



**Figure 1.** Defects and common causes of aluminium facade.

## Natural stones

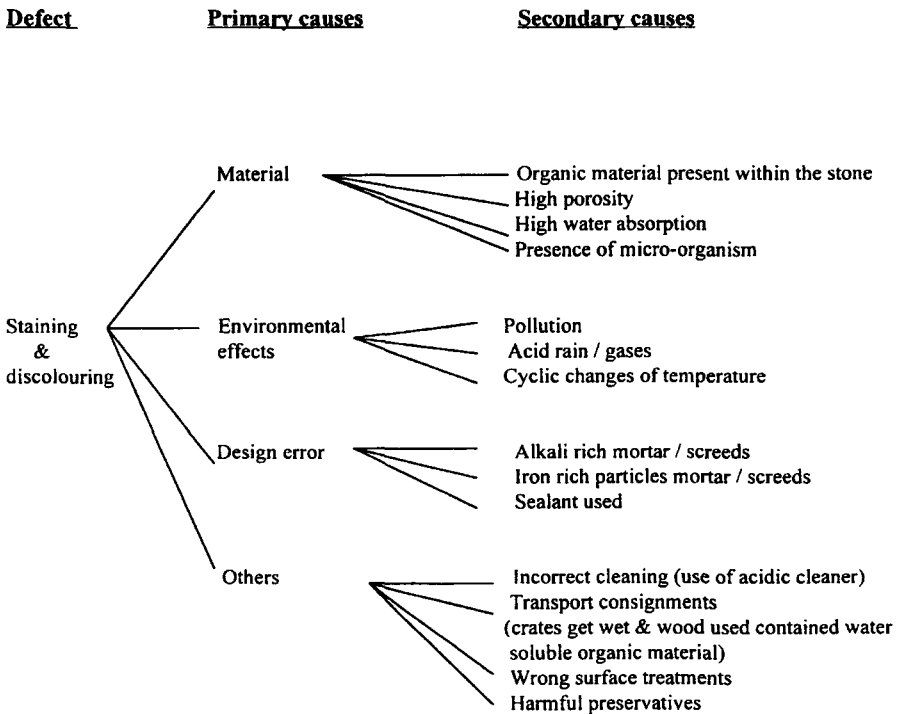


Figure 2(a). Defects and common causes of natural stone facade.

### Natural stones

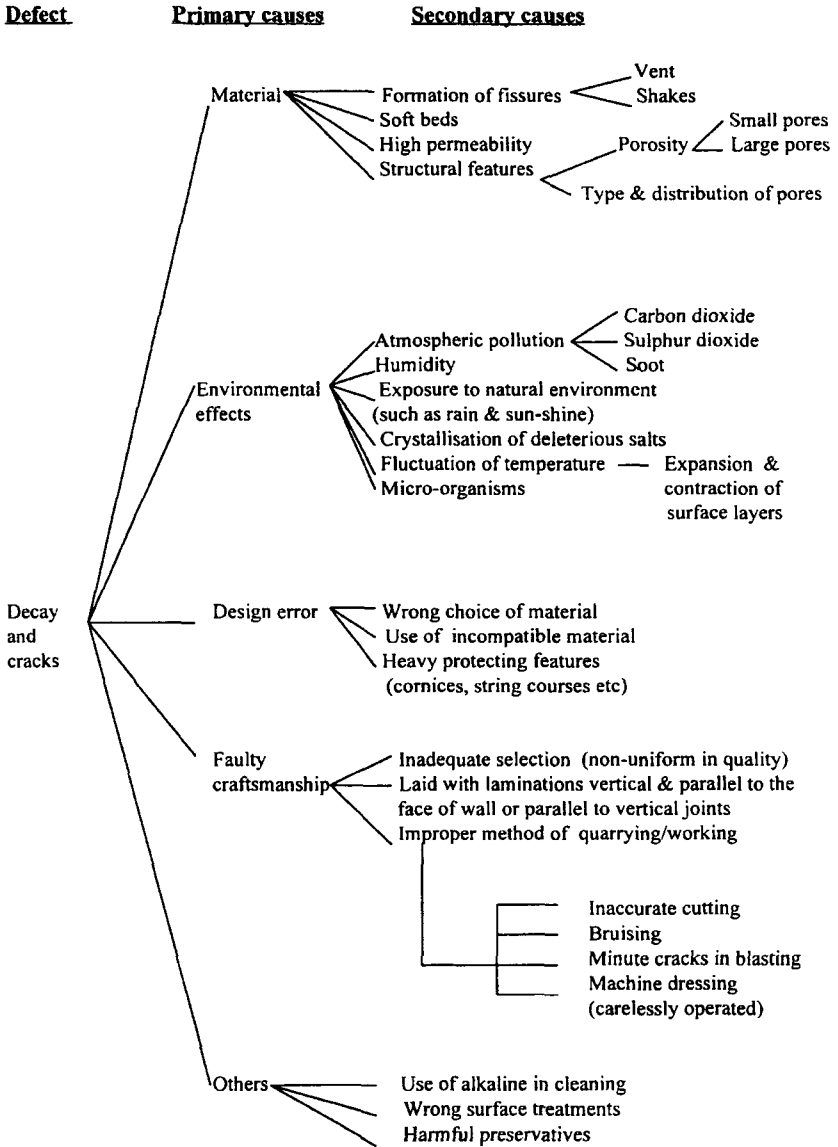


Figure 2(b). Defects and common causes of natural stone facade.

## Glass

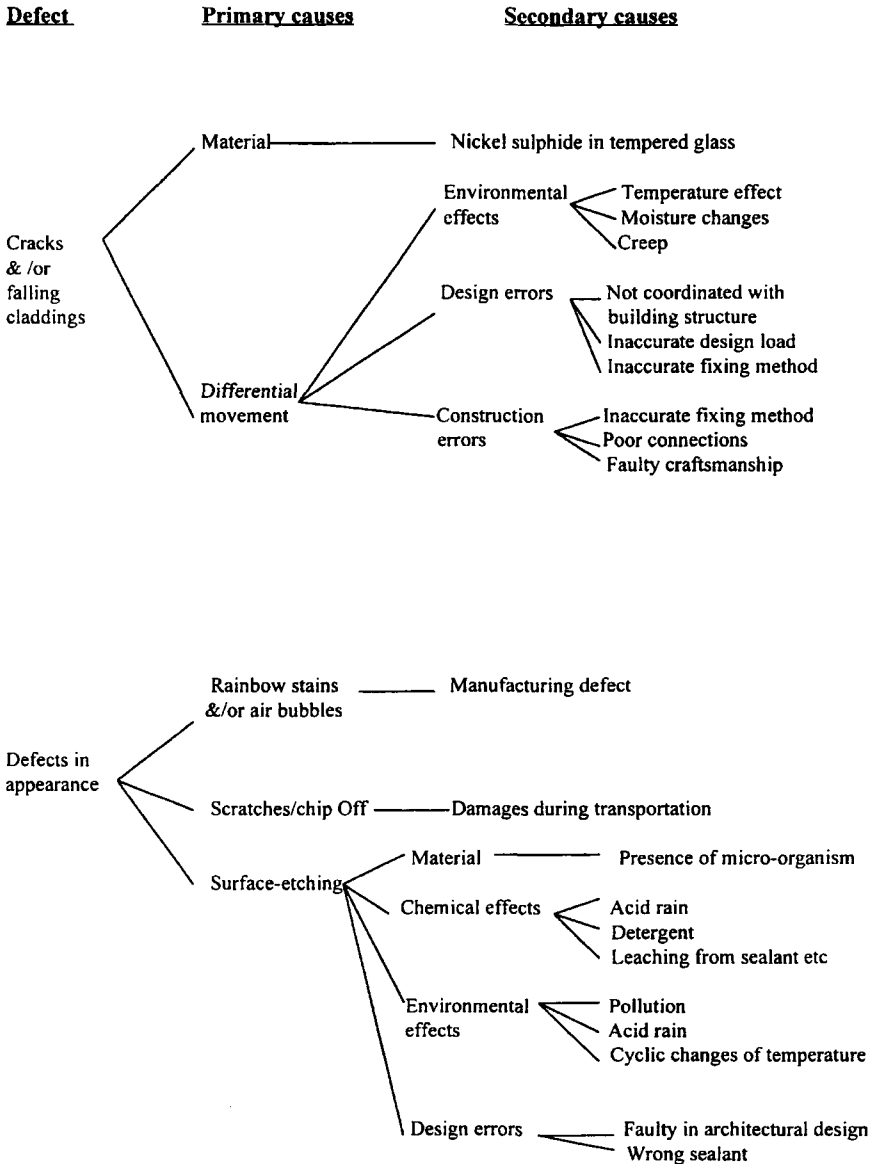


Figure 3. Defects and common causes of glass facade.

Aluminium panels anodised under a controlled oxidising process can be subjected to the risks of corrosion due to careless handling which scratches off the protective layer, wrong use of fixing accessories, chipping off of coating at weak points such as the corners or edges of the panels and insufficient sealant depth which allows water from the upper floor to flow through the joints. The warping of panels is due mainly to the torsion of the bending edges on the four sides of the panels. The joint design and tolerance that allow for movements due to various loadings, moisture and temperature variations, movement of connecting elements, etc., are critical. Surface erosion of coating normally occurs when rain water constantly flows down a specific path. The lighter colours mark the paths where the rain water flows. This problem is mainly attributed to the drainage design and detailing. The discolouration of anodised and coated aluminium is mainly due to the ultra violet rays of sunlight. It was found to be more severe on the dark coloured coating than the lighter coloured.

In the case of natural stone cladding, the common problems observed include staining, cracking and water movement.

The main causes of staining are the porosity and water absorption properties of natural stones, efflorescence or leaching out of salts from mortars and/ or adhesives, improper detailing of joints and deterioration of sealants.

The ability to take up water quickly combined with a high natural porosity result in the rapid discolouration of some stones. Capillary action of moisture from the ground could also cause surface staining of the stone panel in contact with the ground floor slab. Efflorescence in precast stone panels is mainly due to the leaching of soluble alkali salts and the like from the cementitious backing. The most common form of staining associated with the use of silicone sealant in stone cladding is the appearance of bands of dust at the edges of the joints. This is a form of pattern staining and is considered to be a result of the inherently strong water-repellent nature of the silicone. As the water flows over the face of a building, it is repelled by the silicone sealant at the joint. This temporarily halts the flow of water and can lead to the deposition of dirt. The migration problem with silicone sealant is the absorption of small quantities of silicone plasticiser by the stone in contact. The problem tends to vary with the different types of stone used but is most pronounced with granite and marble. Cracking in stone cladding appears either as horizontal

or vertical fractures on the surface of panels. The cracking may be formed on an individual panel or spread across a few panels. The two main causes of cracking on stone panels are deformation of the reinforced concrete structural frame and differential thermal movement of the concrete backing and stone cladding. Other causes include differential settlement of the frame, inaccuracy in positioning of fixing, holes and slots, and improper joint design.

The major causes of staining on glass facade are environmental effects, improper detailing, biological factors and deterioration of sealants. The natural characteristics of glass make it difficult for it to be kept clean. Glass is hydrophilic, i.e. it attracts and holds a molecular layer of moisture on its surface and this in turn traps dust and dirt. In addition, it does not conduct electricity, so static electrical charges generated by surface function are not readily dissipated and attracts dirt to its surface. Efflorescence may appear on glass facades with cementitious adhesives and/or backing. Joints without adequate internal drainage and weep systems lead to internal water movements and hence efflorescence. In addition, the trapped moisture also creates other problems such as the growth of micro-organisms, deterioration of sealants, environmental stress corrosion, etc.