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CERAMIC TILE FAILURE IN A DAIRY PROCESSING PLANT

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CERAMIC TILE FAILURE IN A
A DAIRY PROCESSING PLANT

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ABSTRACT

This paper describes the failure of ceramic tiles used for internal wall finish in a new dairy processing factory because of a disregard for the basic methods that permit movement of materials without problems; movement that is inevitable where there are areas of high humidity and 'free' water.

The failure involved thousands of tiles and very likely the cost of remedial work will cost thousands (of dollars) too. Hygiene standards were also put at risk, and production figures hazarded.

Where specialist work is required, specifications must be detailed and clear with reference to the relevant standards to ensure adequate guidance and control of any sub-contractor.

Reference to vague or non-existent literature from a manufacturer by the specifier is likely to invite failure, especially where materials are to be used where conditions are extreme.

KEYWORDS

Adhesives; Concrete; Factories; Fired clay; Wall tiles.

This paper highlights the problems, pinpoints the causes of failure and provides recommendations with the aim of avoiding future failures for the designer/builder, and loss of production and delays for the client.

INTRODUCTION

As a technical adviser at the Building Research Association, the writer is contacted on a wide range of subjects and problems. While authors - scientists and engineers who work in a particular field - write great quantities of useful information on their subject, those who specify and those who actually do the work rarely make enough use of this information. We can all think of reasons why this happens depending on our particular slot in and perspective of the building process. Maybe there is an inbuilt resistance to obtaining written advice, maybe there's a lack of awareness that the information exists, but usually there is simply a lack of awareness of the need to prepare the method of operation.

Whatever the reason, this basic omission of "checking out the best way to do the job" provides a common cause for failure in the short or long term. The problems caused by a failure often compound when the building is nearing completion or occupied. These problems may continue for the life of the building but usually they have to be remedied after occupation. The work can be major and expensive.

In the food processing industry maintenance work is always a problem and attempting to put right failures that occurred during construction are disruptive and costly. With good planning and on-site preparation many such failures would be avoided.

PROBLEM

This paper outlines a failure with ceramic tiles used in a dairy factory as wall linings. Unfortunately, the information on how to do the job correctly arrived two years after the factory was completed.

The contract was let to a tiler based some 100 miles away. When the time came to do the substantial work the company sub-let the work to a local tiler based only a few miles from the site. Already the seeds of failure were starting to germinate.

The writer inspected the factory while it was still operational. There were three large processing areas where the walls were lined with tiles. Failures occurred at random over about 5% of these walls. As expected, the temperature was close to 30°C with

generous amounts of water on the floors producing very high relative humidity. Vibration also occurred in some areas, produced by the working of heavy plant.

During two years of production by the dairy factory the glazed ceramic tiles persisted in falling off the walls, to the concern of the designer and main contractor - not to mention the persons concerned with hygiene levels. Then the Building Research Association was asked to inspect and provide recommendations on how to overcome the problem. The request included urgency as the annual shutdown was near and maintenance work had to be done in that period.

What were the reasons for the failure of the ceramic tiles on this job? Many, and each one needs to be discussed in detail.

INSTALLATION

This two year old dairy processing factory had a wall area of approx 900 square metres lined with imported ceramic tiles (150x150x6mm) and approximately 40 square metres of these tiles had failed. In units this means that some 4000 tiles needed reinstatement. In the three processing areas where the failures had occurred, the tiles covered the walls to a height of 3.3 metres. Included in these walls were aluminium borrowed lights and double door openings. The first rows of tiles sat on the coved concrete upstand.

As mentioned earlier temperatures in the tile areas were close to 30°C and humidity was high. Condensation on the face of the tiles in some areas was heavy. Surface water from plant ponded on the floor because of inadequate drainage and contributed to the high humidity.

On the areas of walls where failure had occurred there were places where the concrete substrate showed through. In other parts still covered by the ceramic tiles the tiles were cracked, bulging, and generally failing. Only vertical control joints spaced at 5 metre intervals had been installed. The filler in these joints had retained its plasticity.

Where tiles had fallen from the walls, a close inspection showed the concrete work to be of a good standard with a clean finish - a result of the concrete walls being designed as precast, tilt-up panels.

The specification for the tiling work provided little information for the contractor. Preparation, workmanship and materials were items the specifier all but avoided, probably because of lack of knowledge and time. However, avoidance of information in a specification and reliance on the experience and integrity of a tiler to install an important component satisfactorily would appear to be inviting trouble if not failure.

Preparation of the substrate and tiles, information on the adhesive and jointing system, control joints, and finish at openings, are all essential items on which the contractor must be given guidance.

PROBABLE CAUSES OF FAILURE

1. The ceramic tiles used were of only medium density. Thus expansion of the tiles in conditions of high humidity was to be expected.

Combined with a degree of shrinkage in the concrete walls, stresses set up can be transferred through the concrete to the prepared surface.

These two factors can influence the stability of the whole tiling system.

2. Insufficient vertical control joints and an absence of any horizontal control joints in those processing areas subject to high humidity.

Compression of the edges of the tiles and subsequent bulging of the tile system results.

3. The absence of control joints at the internal corners and at door openings would contribute to adhesion problems.

Where materials with greatly different expansion and contraction properties, such as aluminium, butt-up to the tiles, and where there are changes of angle (internal corners), unwanted stresses occur.

4. Because the design included pre-cast panels, a release agent was used. Any residue of release agent-retarder can cause adhesion problems.

Speed of construction reduces weathering time and amount of sunlight on the panels. Therefore the two vital elements required to breakdown a retarder may have had too little time to act on the panels - or some of them. Again adhesion problems can result.

5. Finally the cement-based adhesives used, if mixed to the proportions recommended by the manufacturer, would be excessively rich.

Equal parts of adhesive and sand mean shrinkage is likely in the curing process, again giving adhesion problems.

Reducing the mix design ratio not only improves the chances of good adhesion but also reduces the cost.

RECOMMENDATIONS

While the reasons for a failure can often be given with relative certainty, giving recommendations on how to overcome the problem is always more difficult. What is more, even though the failure can occur over many months the "how to fix" reply is wanted quickly and concisely.

1. In failed areas the substrate needs thorough preparation and cleaning to remove the original adhesive system. Laitence, too, should be removed from the concrete substrate. Wire-brushing and scabbling to expose the aggregate is necessary and, of course, the back faces of the tiles need thorough cleaning also.
2. After the preparatory work is done, setting-out is needed to provide for more control joints along and across the tiled areas. For areas of high humidity or other severe conditions, control joints - horizontal and vertical at no more than 3.0 metre centres - are essential to avoid compressive and other stresses that are sure to occur.

Each movement joint should be at least 6mm wide and of a depth at least equal to the combined thickness of the tiles and the bedding mortar. Any control joints already in the structure must not be tiled over but carried through to the face of the tiling. The joints should be kept free of solid material and raked out before filling, and the filler must remain pliable and waterproof.

3. While the same adhesive system was recommended, reduced strength of the mix design was suggested. Special attention to correct application, working time and mixing should also be noted.

The original mix design (1:1 ratio) strength was considered to be excessively strong and likely to promote adhesion problems.

Reduction of the mix design to a ratio of one part adhesive three parts sand would increase the chances of good adhesion of the tiles.

Strong mix design of adhesives, like strong mix design of plaster, is unnecessary and expensive. When cement is included in an adhesive some shrinkage is inevitable. Therefore the adhesive must be carefully prepared with all ingredients proportioned correctly.

COMMENT

The tiling of internal walls deserves greater attention from both designers and contractors. Good communications between all those involved is vital. The specifier contractor and owner must know how the work is best done. Knowing how to achieve it and what to avoid can only produce good results.

The failures in wall tiling in recent years are probably a reflection of the faster rate of construction work.

This time factor and moisture are basic to many of the problems that are occurring on site. Often the essential properties of building materials are ignored with consequent severe failures of finishes such as wall tiling.

All materials forming the background for ceramic wall tiles should be adequately cured or protected against moisture uptake. This not only applies to reinforced concrete but to all substrates. However, concrete undergoes high initial movement after manufacture or after casting on site. Thus when insufficient curing time is allowed prior to the fixing of tiles, the resulting differential movement may cause failure.

Selection of quality tiles is another important prerequisite for any tiling job and the writer suggests that designers and contractors refer to British Standard 5385 Pt I as a prime reference for most of the information needed to achieve good design and satisfactory performance.

Failures are costly and disruptive.

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