

# CERAMIC WALL TILING ONTO GYPSUM PLASTER BACKGROUNDS

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## ABSTRACT

*The paper will review the history of ceramic wall tiling onto gypsum plaster, using proprietary adhesives. The author will highlight some of the problems which have occurred during the last 30 years and will describe the solutions which have been devised. Those topics discussed will include the relevance of drying times, surface conditions and preparation, priming and the choice of tiles.*

*The suitability of gypsum plaster as a background for tiling in specific locations will be examined, using examples of actual locations.*

*The results of co-operative work with the plaster manufacturers will be discussed and these will be used to illustrate how changes to the recommendations for tiling onto modern lightweight multi-finish plasters have been introduced.*

## INTRODUCTION

The first commercially available ready mixed adhesive in Europe was developed in the UK in 1951 and was based on an organic solution of a reclaim rubber compound. With the advent of proprietary ready mixed adhesives it became possible to tile direct to gypsum plaster backgrounds. The change from traditional cement/sand fixing to adhesives, gradually began to gain momentum during the 1950's but it was not until the emergence of water-borne adhesives based on polyvinyl acetate, in 1959, that adhesive fixing onto a wide range of substrates, including gypsum skimmed plasterboard and gypsum coated bricks, blocks and concrete really revolutionised

ceramic wall tiling.

During the 50's and early 60's the pace of construction was still relatively slow and the majority of building materials in use were traditional, stable components, e.g. well-fired clay bricks. Thus, the ceramic tile installation was not necessarily subjected to high levels of background stress and hence problems were rare.

In the late 60's several factors began to influence the performance and durability of ceramic wall tiling. The pace of construction quickened greatly towards what we now call "fast tracking"; a new generation of building materials began to become well established, including lightweight concrete blocks, dry wall partitions and lightweight gypsum plasters. High rise structures, using these new materials began to spring up in most towns and cities, creating more potential background movement stresses. These changes led to greater pressure on contractors to complete their operations in a shorter time and time intervals between the different trades were squeezed very tightly. As the finishing trade ceramic tiling contractors were often required to try to make up time lost earlier in the contract. The time intervals between completion of gypsum plastering or rendering and the commencement of tiling was, in many cases, far shorter than the time intervals recommended in the National Codes of Practice.

In the case of gypsum plaster, the plaster manufacturers have always insisted on a 4 week drying time between completion of plastering and the start of tiling. This is to ensure that the plaster has not only had the chance to dry out properly but has also been able to mature to a sufficient strength to support the weight of tiling. In the "fast track climate" 4 week time intervals, especially at the end of the contract, were seen as totally unacceptable and tiling contractors were being asked to tile onto plaster which was only a few days old.

Prior to the introduction of proprietary adhesives for tiling, plastering contractors normally had to finish the plaster to receive paint, wallpaper or similar lightweight wall coverings. This often resulted in a highly polished surface which brought the plaster fines to the top, not a suitable background to receive a heavy cladding such as ceramic tiles. Lightweight gypsum plasters, such as Carlite or Sirapite, dominated the market and were, by their nature, a little weaker than the traditional plasters.

The use of solvented primers helped to consolidate the surface strength of the finish coat of plaster but this treatment did not allow the recommended time intervals to be shortened.

In an attempt to overcome the time pressures some tiling contractors began to advocate tiling directly onto the backing coat of gypsum, leaving off the finish coat. Unfortunately the more open, porous and weak texture of gypsum backing coats produced their own problems and this practice was soon outlawed.

During the 1960's a parallel development to ready mixed ceramic tiling adhesives was the development of the cementitious thin-bed adhesives. This combined the advantages of a proprietary easy-to-use adhesive, with no risk of mixing errors, no soaking of tiles, etc., with the proven strength and durability of a cement/sand mortar. However, these new thin-bed mortars were only recommended onto cement-compatible backgrounds, such as cement/sand rendering, concrete,

brickwork, etc. Most of the formulations at that time tended to be very rich in cement, some as high as 98% which restricted the bed thickness at which the adhesive could be used to 3mm maximum. Thicker beds led to tile crazing and body cracking. The high strength and potential shrinkage prohibited their use on weak backgrounds, such as lightweight gypsum plasters. Thirty years ago many adhesive manufacturers did not fully understand the mechanism of ettringite formation when gypsum, cement and water are brought together, hence this was not a factor in considering the suitability of cementitious adhesives onto gypsum plaster backgrounds.

The low raw material cost of cement and sand compared to polymer emulsions led some manufacturers to launching modified cementitious adhesives for use onto gypsum plaster. In order to reduce the effects of shrinkage the cement content was lowered to below 30% and to compensate for the loss of binding power casein and polyvinyl alcohol were used.

One well known manufacturer at this time believed that this type of formulation, especially with the casein present, would enable tiling to be carried out onto gypsum plaster which was only 24 hours old ("green plaster"). As he also made his product available at a very low price this seemed to be the answer to the tiling contractors' and the industry's prayers. Large quantities of this product were used in commercial tiling and soon other manufacturers jumped onto the bandwagon.

This then was the scenario in the late 1960's.

|                   |   |
|-------------------|---|
| Wall construction | - lightweight concrete blocks.                        |
| Wall finish       | - two coat gypsum system (lightweight finish plaster) |
| Tile adhesive     | - low cost cementitious                               |
| Site conditions   | - cold and damp for about 5 months of year.           |

Time intervals between completion of blockwork and start of plastering - about 3 weeks.

Time interval between plastering and tiling - 2 days.

Building completed in, say, early Spring, still feels cold and damp when occupants move in.

Heating switched on to high level.

**Result** - Within 3-6 months tiles fall off wall. Separation almost clean between adhesive and plaster, with some ettringite formation.

By the end of the 1960's over 50% of all tiling problems occurred onto gypsum plaster backgrounds.

There were principally four modes of failure which could occur.

1. Failure between backing coat and wall - generally due to background contamination, e.g. mould release oil on concrete, inadequate background preparation or use of the wrong type of backing coat plaster.

This type of failure was uncommon. When it occurred the tiles came away from the wall with the adhesive firmly bonded to both the back of the tile and the finish

coat of plaster, with the whole of the backing coat firmly adhered to the plaster finish coat.

2. Separation between the finish coat and backing coats of gypsum. This was generally caused through the lack of a sufficient mechanical key between the two plaster coats; again not a common problem.

3. Cohesive breakdown within the finish coat of plaster. This took the form of a distinct layer of gypsum bonded to the back of the adhesive, which in itself was still very securely bonded to the back of the tile. This type of failure was often associated with tiling too early onto "green" plaster, when the plaster was not of adequate strength to support the weight of tiling and the stresses associated with drying shrinkage of a new building.

4. Failure between adhesive and surface of gypsum plaster with adhesive having a very fine dusting of plaster or particles of plaster surface on its back. This type of breakdown was usually associated with a highly polished or over-trowelled plaster surface.

The increased incidence of adhesion problems onto gypsum plaster became of great concern to the whole industry, with the manufacturers being particularly alarmed about the likely impact on the reputation of ceramic tiling as a hard wearing, durable and decorative finish.

In an attempt to rectify this trend members of the British Ceramic Tile Council co-operated with the National Federation of Plastering Contractors to produce a 10 point plan for successful tiling onto gypsum plaster. These recommendations were published in this blue booklet.

Among the recommendations were the following:

1. 4 week minimum drying time for plaster and dry throughout.
2. Tile only to finish coat, never backing coat.
3. Check for soundness.
4. Apply binding coat of suitable solvent based primer.
5. Avoid excessive trowelling.
6. Adhesives based on polyvinyl acetate are most suitable.
7. Gypsum plaster not a satisfactory base for tiling in wet areas.

When the British Standard Code of Practice for internal wall tiling was revised in 1972 the use of cement-based adhesives for tiling onto gypsum plaster was outlawed. By then those cementitious products which had been recommended for tiling onto fresh plaster had been withdrawn from the market. One company in particular had to pay out over £0.5m (125 million pesetas) in compensation - needless to say they ceased production of ceramic tile adhesives. It should be pointed out that tiling onto gypsum plasterboard rarely gives problems.

For the next 20 years failure levels onto gypsum plaster backgrounds fell to acceptable levels as more people in the industry began to accept the recommendations in the BCTC/NFPC leaflet and those contained in the British Standard Code of Practice.

This, despite the fact that the time pressure became more intense with the development of more sophisticated fast tracking techniques in construction.

During the latter part of this period some adhesive manufacturers again began to promote the use of cementitious adhesives onto gypsum plaster. The advancement of powder technology and the development of more appropriate water-borne primers greatly reduced the risks that were associated with the use of the early cement-based adhesives. The availability of re-dispersible polymer powders enabled cement levels to be reduced, reducing shrinkage, but without sacrificing adhesion. Improved primers allowed both good compatibility with the substrate and adhesive whilst maintaining physical separation between the cement and the gypsum, thus preventing ettringite formation. The industry Code of Practice recognised this change in technology by granting a concessionary approval - it actually advises potential users to consult the individual adhesive manufacturers, rather than outlawing the use of cementitious adhesives on gypsum plaster.

Many manufacturers of ready mixed adhesives had taken their solvented primers off the market and declared that properly applied gypsum plaster, i.e. not over-trowelled, did not need priming when tiling with modern dispersion adhesives.

A reversal of the downward trend in tiling problems onto gypsum became apparent during 1994 when several adhesive manufacturers began to observe a disturbing trend in failure patterns. There was a sharp increase in failures involving the use of ready mixed paste adhesives onto a type of gypsum plaster which had not been marketed for too long and which was generically called "Multi Finish Plaster".

Multi Finish Plaster may be applied onto a cement/sand backing or onto conventional gypsum undercoats. Its ease of application and general trowelling properties have made it very popular with plastering contractors, so much so that it constitutes about 75-80% of the finish plaster market in the UK at this time.

It became apparent that the majority of problems appeared to be occurring where the undercoat was cement/sand. The nature of the breakdown in adhesion of the tiling was generally at the adhesive/plaster surface interface with separation being almost clean to the naked eye. Microscopic examination revealed a very fine pink layer present on the back of the adhesive film. Further investigation revealed that where this type of failure took place the surface of the Multi Finish Plaster was very smooth and close textured and possessed a satin sheen, an appearance that would normally be regarded as being indicative of over-trowelling.

As the extent of the problems grew and spread to many different parts of the country tiling contractors became reluctant to apply ceramic tiles to Multi Finish Plasters; some openly refused contracts.

Clearly this was a situation which could not be allowed to continue. My company approached the gypsum plaster manufacturers and we agreed to carry out some preliminary and very practical evaluations on the effect of surface finish and surface treatment on the bond between adhesive and gypsum plaster.

Prepared concrete blocks coated with a two gypsum system were supplied by the gypsum plaster manufacturers. On one set the surface of the Multi Finish coat was left

with a flat, matt finish whilst a second set was prepared with a polished or shiny finish on the plaster.

Four surface conditions were examined for each of the two sets, namely:

- (a) As received (no preparation).
- (b) Primed.
- (c) Brushed.
- (d) Brushed and primed.

50mm. x 50mm. tiles were fixed in a standard ready mixed adhesive. Tensile adhesion tests were carried out in accordance with the new European Standard, after 14 days air drying.

The following data summarises the results.

**ADHESION TESTS ONTO MULTI FINISH PLASTER**

Comparison of samples of multi finish plaster received from British Gypsum, flat trowelled compared to polished, to assess the effect of surface condition on adhesion and mode of failure.

samples made: 27/02/95

samples tested: 13/03/95

**1 FLAT TROWELLED**

a. As received

| No.  | Tensile Strength<br>N/mm <sup>2</sup> | Failure Mode   |
|------|---------------------------------------|--|
| 1    | 0.72                                  | plaster finish coat/undercoat interface                    |
| 2    | 0.68                                  | plaster finish coat/undercoat interface                    |
| 3    | 0.80                                  | cohesively in the undercoat layer of the plaster substrate |
| 4    | 0.74                                  | cohesively in the undercoat layer of the plaster substrate |
| MEAN | 0.74                                  |  |

b. As received + Primer

| No. | Tensile Strength<br>N/mm <sup>2</sup> | Failure Mode   |
|-----|---------------------------------------|--|
| 1   | 0.76                                  | cohesively in the undercoat layer of the plaster substrate |
| 2   | 0.80                                  | cohesively in the undercoat layer of the plaster substrate |
| 3   | 0.88                                  | cohesively in the undercoat layer of the plaster substrate |

| No.  | Tensile Strength<br>N/mm <sup>2</sup> | Failure Mode   |
|------|---------------------------------------|--|
| 4    | 0.72                                  | cohesively in the undercoat layer of the plaster substrate |
| MEAN | 0.79                                  |  |

c. Brushed

| No.  | Tensile Strength<br>N/mm <sup>2</sup> | Failure Mode   |
|------|---------------------------------------|--|
| 1    | 1.06                                  | cohesively in the undercoat layer of the plaster substrate |
| 2    | 1.02                                  | plaster finish coat/undercoat interface                    |
| 3    | 1.04                                  | cohesively in the undercoat layer of the plaster substrate |
| 4    | 1.04                                  | cohesively in the undercoat layer of the plaster substrate |
| MEAN | 1.04                                  |  |

d. Brushed & Primer

| No.  | Tensile Strength<br>N/mm <sup>2</sup> | Failure Mode   |
|------|---------------------------------------|--|
| 1    | 0.64                                  | cohesively in the undercoat layer of the plaster substrate |
| 2    | 0.56                                  | cohesively in the undercoat layer of the plaster substrate |
| 3    | 0.60                                  | cohesively in the undercoat layer of the plaster substrate |
| 4    | 0.72                                  | cohesively in the undercoat layer of the plaster substrate |
| MEAN | 0.63                                  |  |

## 2 POLISHED

a. As received

| No.  | Tensile Strength<br>N/mm <sup>2</sup> | Failure Mode                          |
|------|---------------------------------------|---------------------------------------|
| 1    | 0.72                                  | adhesive/ finishing plaster interface |
| 2    | 0.54                                  | adhesive/ finishing plaster interface |
| 3    | 0.78                                  | adhesive/ finishing plaster interface |
| 4    | 0.60                                  | adhesive/ finishing plaster interface |
| MEAN | 0.66                                  |                                       |

b. As received + Primer

| No. | Tensile Strength<br>N/mm <sup>2</sup> | Failure Mode                          |
|-----|---------------------------------------|---------------------------------------|
| 1   | 0.80                                  | adhesive/ finishing plaster interface |
| 2   | 0.64                                  | adhesive/ finishing plaster interface |

| No.  | Tensile Strength<br>N/mm <sup>2</sup> | Failure Mode                          |
|------|---------------------------------------|---------------------------------------|
| 3    | 0.56                                  | adhesive/ finishing plaster interface |
| 4    | 0.52                                  | adhesive/ finishing plaster interface |
| MEAN | 0.63                                  |                                       |

c. Brushed

| No.  | Tensile Strength<br>N/mm <sup>2</sup> | Failure Mode                          |
|------|---------------------------------------|---------------------------------------|
| 1    | 0.80                                  | adhesive/ finishing plaster interface |
| 2    | 0.68                                  | adhesive/ finishing plaster interface |
| 3    | 0.64                                  | adhesive/ finishing plaster interface |
| 4    | 0.64                                  | adhesive/ finishing plaster interface |
| MEAN | 0.69                                  |                                       |

d. Brushed + BAL-Bond SBR

| No.  | Tensile Strength<br>N/mm <sup>2</sup> | Failure Mode  |
|------|---------------------------------------|---|
| 1    | 0.56                                  | plaster finish coat/ undercoat interface                          |
| 2    | 0.56                                  | plaster finish coat/ undercoat interface                          |
| 3    | 0.72                                  | plaster finish coat/ undercoat interface                          |
| 4    | 0.72                                  | 25% cohesive plaster substrate<br>75% adhesive/ plaster interface |
| MEAN | 0.64                                  |   |

## CONCLUSIONS

1. When the plaster was flat-trowelled, good adhesion was achieved between the adhesive and plaster coat in all cases. It also gave greater figures for tensile strength than when the plaster surface was polished.
2. When the polished surface was brushed and then coated with two coats of primer, failure occurred at the finish/ undercoat interface of the plaster, not at the adhesive/ plaster interface.
3. This would indicate that over trowelling may actually contribute towards a reduction in the bond strength between the plaster finish coat and undercoat.
4. The results also show that priming alone is not necessarily beneficial and may, in fact, be detrimental where the plaster surface is smooth and shiny.
5. The only universal recommendation which can be made is to stiff brush and prime prior to tiling.



Whilst this work was being undertaken the calls for urgent action from the National Master Tile Fixers Association became more widespread and more vociferous. Some contractors wanted a complete ban on tiling onto Multi Finish Plaster. There was a growing belief that “normal” trowelling of Multi Finish Plaster could result in a shiny surface. It was agreed that an Action Group should be set up with all interested parties represented, with a view to coming up with a consensus of opinion on the way forward.

The following bodies were present at the meeting:

British Gypsum.

Federation of Plasterers and Dry Wall Contractors.

British Adhesive and Sealants Association.

National Master Tile Fixers Association.

At the first meeting a comprehensive exchange of information and experiences took place and it was clear that adhesive manufacturers and contractors had common problems. Failure usually occurred at the adhesive/plaster interface. Other common factors included; the undercoat was usually cement/sand; problems occurred some months after installation and the plaster surface had a satin or shiny surface.

While it was generally agreed that a flat trowelled matt finish on the finish plaster did not necessarily require priming before tiling with a ready mixed adhesive it was felt that a single set of recommendations was needed for all to follow, otherwise it left the decision on surface preparation entirely in the hands and judgement of the man on site.

Therefore, the only reliable procedure was to dry brush the surface with a stiff-bristled brush followed by priming with a suitable primer, e.g. acrylic dispersion type. In order to formalise and publicise the recommendations it was decided to publish a brochure, along the lines of the old BCTC/NFPC booklet. The new publication would be endorsed by NMTFA/FPDC/British Gypsum. The essential elements of the recommendations are as follows:

1. Although ceramic tiles can be fixed to a wide variety of backgrounds with appropriate adhesives, most tiling is fixed onto cement-sand rendering, gypsum plaster systems or onto plasterboard.
2. Cement-sand rendering is the preferred background for tiling and detailed guidance is provided in British Standard Code of Practice BS5385 Wall Tiling (Part 1:1995, Part 2:1991 and Part 4:1992). Less information is provided about gypsum plaster backgrounds and this joint statement has been prepared in order to emphasise the conditions under which gypsum plaster can be safely used as a suitable background for ceramic tiles.  
The essential points to note are:
3. It is very important that the masonry background is thoroughly dry. A minimum of six weeks should have been allowed between the construction of the masonry background and plastering. The presence of moisture in the background will not always be visually evident.
4. This is particularly important where gypsum plastering is to be applied onto

concrete walls especially if of lightweight or aircrete (aerated concrete) blocks or onto insitu concrete walls or onto cement-sand rendering.

5. **CAUTION:** Cement-sand rendering dries gradually with shrinkage taking place. If a cement-sand undercoat is not cured and dried prior to plastering and tiling, the subsequent drying shrinkage of the rendering can break the adhesion between the undercoat and finish coat of gypsum or between the finish and tile adhesive causing failure. New concrete walls require a longer drying time to allow shrinkage to take place, otherwise similar problems will occur.
6. Plastering should be done in accordance with the recommendations given in BS5492:1990 and modified in BS5385 Part 1:1995 sections 3.3 and 3.4. The plasterwork should be firmly adhered to its background and be sufficiently strong to support the specified tiling.
7. The maximum weight of tiling which can be supported by a dry, well-adhered plaster background is 20kg/m<sup>2</sup>, generally equivalent to ceramic tiles with a thickness of 8mm or natural stone tiles with a thickness of 7mm. When fixing directly to unskimmed paper-faced plasterboard surfaces the maximum permissible weight is increased to 32kg/m<sup>2</sup>. These weights include adhesive and grout.
8. Proprietary gypsum based systems are recommended because both the undercoat and finish are designed to work together. Advice on which finish coats work with which undercoats is available from the manufacturers.
9. Gypsum plaster must be thoroughly dry before tiling. New plasterwork consisting of undercoat and finish coat should have been completed at least 4 weeks before tiling is commenced. **Tiles should never be fixed to plaster which is not dry throughout.** Where drying is assisted by space heating or dehumidifying, care should be taken to ensure that the plaster is not just dry at the surface. The heater or dehumidifier must not be directed at the plasterwork.
10. It is important to understand that some gypsum plasters may appear dry on the surface whilst still containing moisture within.
11. Use of non-invasive radio frequency moisture meters will be of help in determining moisture levels still within rendering/plastering and/or the background.
12. When it is known in advance that tiles are to be fixed to a plastered wall, it is essential that there should be good adhesion between the undercoat and the plaster finish coat. Tiles should only be fixed to the finish coat and must not be fixed directly to a gypsum undercoat.
13. The finish plaster should be specified and applied to provide a matt finish. **Excessive trowelling of the plaster to "improve" its appearance must be discouraged, since this practice may result in a dusty or shiny surface which is not suitable for tiling.** If the finish plaster is hard and sound but has dusty or friable residues on its surface, the surface should be thoroughly

brushed down. If trowelling of the surface has produced a shiny and smooth surface, this must be removed by vigorous brushing. Where the use of a primer is recommended before the tiles are fixed the recommended primer should be applied strictly in accordance with the manufacturers instructions.

14. Every plaster surface should be examined carefully by the tile fixer before any tiling work is undertaken, paying particular attention to surface finish. In addition, it is important to sound the whole area carefully for any evidence of hollowness or lack of complete adhesion in the backing. Any such defects must be remedied by cutting out and replastering before tiling. The repair must also be allowed to fully dry out.
15. On old plastered surfaces any decaying or loose areas must be cut out and made good.
16. Sometimes painted plaster surfaces are encountered. Hard gloss paint if well bonded is usually a satisfactory base for tiling, but any paint showing signs of flaking should be removed. Emulsion paint or distempers can breakdown after tiling and must be removed mechanically prior to tiling.
17. The surface to receive the tiles must be clean, sound and dry.
18. Since thin-bed adhesives not exceeding 3mm bed thickness are generally specified for fixing tiles to plaster, the plaster surface should be plumb, true and level. Trueness of surface should be such that when checked with a 2m. straightedge, any gap between points of contact should not exceed 3mm.

*Note:* However such close tolerances of the trueness of a plastered surface will not have been attained unless the surface was specified to be tiled prior to plastering and the appropriate specification for plasterwork defined.

19. Explanation - a plastered surface, which is not to be tiled, is not required to meet such tolerances. Thus consideration should be given to indicating these areas within the Bill of Quantities and the specification to ensure the opportunity is given to providing the correct specification and tolerance factor.
20. Generally, ready mixed adhesives conforming to Type 2, BS5980 are appropriate for fixing ceramic tiles to properly prepared plaster backgrounds. Where fully-vitrified large format tiles (under 20kg/m<sup>2</sup>) are to be fixed the recommendations from the adhesive manufacturer regarding adhesive and surface preparation should be sought.
21. Plaster is not a satisfactory base for tiling in wet areas, eg showers compartments. Reference should be made to BS5385 part 4:1992 for tiling in wet areas. If the backing consists of existing gypsum plaster seek the adhesive manufacturer's advice on suitable waterproofing systems.

To further emphasise the importance of surface preparation the British Standards Institution is to issue an amendment to the Code of Practice, in accordance with the

industry-agreed guidelines. In this way it is hoped to reverse the trend once again of failure onto gypsum plaster backgrounds and to strengthen the reputation of ceramic tiling as a long lasting, durable, decorative cladding system for all types of installation. Let's hope so.