Comparative Investigation on Properties of Various Local and Imported Terrazzo Tiles

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Abstract. The paper aims to study the properties of various local and imported terrazzo tiles manufactured by ten different factories. Five of the terrazzo tile samples are local while the others are imported from Turkey and Iran. Thirty samples have been tested for each factory with total number of 300 tiles. Samples of tiles have been randomly selected from local market and then tested according to the testing methods of terrazzo tiles and ordinary tiles (31, 1989) and compared with Iraqi specification (1042, 1984). Tests result showed that all local samples conform to the specification while imported samples do not conform to Iraqi specification. The Turkish samples were out of tolerances in thickness (-15, -13 mm) for both samples. The Iranian samples were out of limits in total absorption test (10.4, 11.6 %) for both sample. The higher modulus of rupture was 7.22 MPa in a Turkish sample. The best abrasion resistance was 1.87 mm average thickness reduction in an Iranian sample. The best result of SO$_3$ content was 0.274% in local sample Kamalyah factory. Over all, according to the adopted specification all local samples can be classified as conformable to specification limits.

1. Introduction
The word terrazzo is derived from the Italian to make any mosaic flooring which made by embedding very small pieces of marble or colour stone in a paste followed by polishing the surface [1, 2]. Terrazzo tiles are also known as mosaic tiles. Cement concrete and pieces of colour stone are the main raw materials used for the manufacturing process [2, 3]. The strength of tiles affected by the nature of raw materials and on the technique of factories [4]. Terrazzo tiles can be used as floor finish for interior and exterior applications because tiles have a long life span and are durable construction material. Terrazzo tiles are the most common type of tiles used in Iraq [5]. The mosaics are used as a type of wall decoration in ancient times, since the Roman period. Mosaics became the main wall decoration in the Byzantine art, in Russia and in the Islamic art (in particular in the Iranian decoration history) [6]. The dimensions of Terrazzo tiles of 300*300*30, 260*250*25 and 200*200*20 mm are widely used and can be produced in two types, single or double layer, with the tiles consisting two layers, the upper exposed to friction conditions, and the lower in contact with the floor material [7].

The objective of this work is to investigate the properties of ten types of terrazzo tiles available in local market and examine the conformity of all tested types with the Iraqi specifications.

2. Experimental Work and Results
This investigation consists of testing properties of various local and imported terrazzo tiles. Total number of 300 samples was tested from six local factories, two Turkish and two Iranian to evaluate
dimensions and shape, water absorption, modulus of rupture, abrasion resistance and sulphate content SO₃%. Designation and sources of the tested samples are listed in table 1.

**Table 1.** Designation and Sources of Tested Samples.

| Samples Source | Source Country | Company Name                        | Samples Designation |
|----------------|----------------|-------------------------------------|---------------------|
| Local          | Iraq           | Al-Tayeb factory                    | L1                  |
|                | Iraq           | Kalala factory                      | L2                  |
|                | Iraq           | Al-Magrib factory                   | L3                  |
|                | Iraq           | Kamalyah factory                    | L4                  |
|                | Iraq           | Al-Sharq Al-Awsat factory           | L5                  |
|                | Iraq           | Sulaimanyah factory                 | L6                  |
| Imported       | Turkey         | Ker Caro (Ali Salah company)        | T1                  |
|                | Turkey         | Kayrz Caro (Al-Qureshi company)     | T2                  |
|                | Iran           | Adel Nia (Al-Wotan company)         | I1                  |
|                | Iran           | Diana (Diana company)               | I2                  |

Details of the experimental program are presented in the following section:-

2.1 **Dimensions and Shape Test**

The tests of dimensions and shape were performed according to guide of testing methods of terrazzo and ordinary tiles [8]. The nominal dimensions of 400*400*35 mm terrazzo tiles were used. Steel ruler, T-square and angles were used as simple devices for measuring and checking equatorial of tiles, face, angles, face and back parallelism, thickness of surface layer and thickness of terrazzo tiles. The average values of readings for each sample were recorded for each dimension. Table 2 gives the test results regarding length, width and thickness for all samples.

**Table 2.** Results of Dimensions Test of Terrazzo Tile Samples.

| Samples | Dimensions (mm) | Tolerance (mm) |
|---------|-----------------|----------------|
|         | Length | Thickness | Length | Thickness |
| L1      | 401    | 38        | +1     | +3        |
| L2      | 401    | 38        | +1     | +3        |
| L3      | 399    | 37        | -1     | +2        |
| L4      | 401    | 38        | +1     | +3        |
| L5      | 401    | 35        | +1     | 0         |
| L6      | 399.2  | 32        | -0.8   | -3        |
| T1      | 399.1  | 20        | -0.9   | -15       |
| T2      | 399.6  | 22        | -0.4   | -13       |
| I1      | 399.2  | 32        | -0.8   | -3        |
| I2      | 399.7  | 32        | -0.3   | -3        |
| Iraqi Specification (1984) Limits | 400 | 35 | ±1 | ±3 |
It can be seen from Table 2 that all terrazzo samples conform to Iraqi Specifications IQS (1042, 1984) [9] except samples T1 and T2 (Turkish) where thicknesses are 20 and 22 mm and tolerances -15 and -13 mm, respectively. This is because T1 and T2 are manufactured with face layer only without back layer as shown in plate 1. However, the tolerance in length for T1, T2 are within the IQS (1042, 1984) [9]. Results also show that the lower permissible tolerance was recorded in sample I2 (-0.3 mm in length) and the higher tolerance in samples L1, L2, L4, L6, I1 and I2 (±3 mm in thickness).

2.2 Water Absorption Tests
Both face absorption test and total absorption test of terrazzo tiles were performed according to guide of testing methods of terrazzo and ordinary tiles [8]. The results of face absorption tests are presented in table 3 and figure 1.

All results of face absorption test are conforming to IQS (1042, 1984) [9]. The sample L4 (local) records the higher value (0.25 gm/cm²) whiles the lower value (0.05 gm/cm²) is recorded for sample L2 (local). For imported samples, face absorption was 0.1 gm/cm² in T1 and T2 (Turkish) and 0.2 gm/cm² in I1 and I2 (Iranian). The results of total absorption are shown in table 3 and figure 2. All results of total absorption were ≤ 8% which conform to the Iraqi Specification (1042, 1984) [9] except samples I1 and I2 (Iranian) where total absorptions are 10.4% and 11.6% respectively. Lower total absorption was 1.7% in sample L2 (local) and the higher permissible total absorption was 6% in sample L4 (local). Total absorption of samples T1 and T2 (Turkish) were 2% and 2.6%, respectively. The higher absorption means presence of higher porosity and voids in the back layer.

| Samples | Face Absorption (gm/cm²) | Total Absorption (%) |
|---------|---------------------------|----------------------|
| L1      | 0.1                       | 3                    |
| L2      | 0.05                      | 1.7                  |
| L3      | 0.17                      | 4                    |
| L4      | 0.25                      | 6                    |
| L5      | 0.1                       | 2.7                  |
| L6      | 0.15                      | 5.8                  |
| T1      | 0.1                       | 2                    |
| T2      | 0.1                       | 2.6                  |
| I1      | 0.2                       | 10.4                 |
| I2      | 0.2                       | 11.6                 |
| Iraqi Specification (1042, 1984) Limits | ≤ 0.4 | ≤ 8 |
2.3 Modulus of Rupture Test

The modulus of rupture test was carried out immediately after absorption test according to guide (31, 1989) [8] for testing, methods of terrazzo and ordinary tiles. The results are presented in table 4 and figure 3 for local and imported tiles. Results show that the modulus of rupture was ≥ 3 MPa for all samples which conform to the IQS (1042, 1984) [9]. However, results for local and imported samples ranged from 3 to 6.23 MPa and from 5.25 to 7.22 MPa, respectively. Sample T1 (Turkish) has the highest modulus of rupture (7.22 MPa) while the lowest (3 MPa) was for sample L5 (local). T1 and T2 have the highest modulus of rupture because they have no back layer which may be the weak layer that crack first in flexural test.

**Table 4. Results of Modulus of Rupture.**

| Samples | Modulus of Rupture (MPa) |
|---------|--------------------------|
| L1      | 3.57                     |
| L2      | 3.515                    |
| L3      | 3.16                     |
| L4      | 6.2                      |
| L5      | 3                        |
| L6      | 6.23                     |
| T1      | 7.22                     |
| T2      | 6.3                      |
| I1      | 6.09                     |
| I2      | 5.25                     |
| Iraqi Specification (1042, 1984) Limits | ≥ 3 |
2.4. Abrasion Resistance Test

The abrasion resistance test was conducted according to IQS (1042, 1984) [9]. Table 5 and figure 4 show the results of abrasion resistance test. Results of abrasion test (average thickness reduction) conform to the IQS (1042, 1984) [9] mentioned above for all samples (≤ 2.5 mm). The test results ranged, in general, from 1.87 mm for sample I1 (Iranian) to 2.22 mm for sample T1 (Turkish).

Table 5. Results of Abrasion Resistance.

| Samples | Average Thickness Reduction (mm) |
|---------|---------------------------------|
| L1      | 2.10                            |
| L2      | 1.98                            |
| L3      | 1.97                            |
| L4      | 2.11                            |
| L5      | 2.19                            |
| L6      | 2.07                            |
| T1      | 2.22                            |
| T2      | 1.92                            |
| I1      | 1.87                            |
| I2      | 1.96                            |

Iraqi Specification (1042, 1984) Limits

≤ 2.5

*The test was performed in the National Centre for Construction Laboratories and Research.

Figure 3. Results of Modulus of Rupture.

Figure 4. Results of Abrasion Resistance.
2.5. Sulphate Content SO₃%

The sulphate content test was conducted according to IQS (45, 1984) [10]. Table 6 and Figure 5 show the results of SO₃%. All results were less than the minimum value of SO₃% (4.5 %) in IQS (45, 1984) [10]. Results of SO₃% are ranged from 0.274% to 4.301% for local sample, from 0.396% to 0.441% for Turkish samples and from 0.63% to 0.674% for Iranian samples. However, the lowest SO₃% (0.274%) was in sample L4 (local) while the highest (4.301%) in sample L5 (local).

Table 6. Results of Sulphate Content SO₃%.

| Samples Symbol | SO₃ Content (%) |
|----------------|-----------------|
| L1             | 3.94            |
| L2             | 0.75            |
| L3             | 4.283           |
| L4             | 0.274           |
| L5             | 4.301           |
| L6             | 4.07            |
| T1             | 0.396           |
| T2             | 0.441           |
| I1             | 0.674           |
| I2             | 0.63            |

Iraqi Specification (45, 1984) Limits ≤ 4.5 %

Figure 5. Results of Sulphate Content.

The Results of tests are summarised in table 7.
Table 7. Summary of the Results.

| Samples Type | Samples | Dimensions | Face Absorption | Total Absorption | Modulus of Rupture | Abrasion Resistance | SO₃% | Conform or Not With Specification |
|--------------|---------|------------|-----------------|------------------|-------------------|---------------------|------|----------------------------------|
| Local        | L1      | √          | √               | √                | √                 | √                   |      | Conform                          |
|              | L2      | √          | √               | √                | √                 | √                   |      | Conform                          |
|              | L3      | √          | √               | √                | √                 | √                   |      | Conform                          |
|              | L4      | √          | √               | √                | √                 | √                   |      | Conform                          |
|              | L5      | √          | √               | √                | √                 | √                   |      | Conform                          |
|              | L6      | √          | √               | √                | √                 | √                   |      | Conform                          |
| Imported     | T1      | X          | √               | √                | √                 | √                   |      | Not Conform                      |
|              | T2      | X          | √               | √                | √                 | √                   |      | Not Conform                      |
|              | I1      | √          | √               | X                | √                 | √                   |      | Not Conform                      |
|              | I2      | √          | √               | X                | √                 | √                   |      | Not Conform                      |

3. Conclusions

Based on the results of the experimental investigation of testing various local and imported terrazzo tiles regarding dimensions and shape, face absorption, total absorption, modulus of rupture, abrasion resistance and sulphate content SO₃%, the following conclusions can be made:

1. Local sample (L1, L2, L3, L4, L5, L6) conform the Iraqi specifications (1042, 1984) for all tested properties.
2. Turkish samples (T1 and T2) conform to Iraqi specifications (1042, 1984) in all tested properties except thickness dimension because they are manufactured with face layer only.
3. Iranian samples (I1 and I2) conform to Iraqi specifications (1042, 1984) in all properties except the total absorption results.
4. The lowest tolerances in tiles dimensions are -0.3 mm in length (Iranian sample I2), -0.3 mm in width (Iranian sample I2), 0 mm in thickness (local sample L5) while the highest tolerances were +1 mm in length (local samples L1, L2, L4, L5), +1 mm in width (local samples L1, L2, L4, L5), -15 mm in thickness (Turkish sample T1).
5. The lowest face absorption was 0.05 gm/cm² in local sample L2 while the highest face absorption was 0.25 gm/cm² in local sample L4.
6. The lowest total absorption was 1.7% in local sample L2 while the highest total absorption was 11.6% in Iranian sample I2.
7. The lowest modulus of rupture was 3 MPa in local sample L5 while the highest modulus of rupture was 7.22 MPa in Turkish sample T1.
8. The best abrasion resistance was 1.87 mm average thickness reduction in Iranian sample I1 while the worst abrasion resistance was 2.22 mm in Turkish sample T1.
9. The lowest sulphate content SO₃ was 0.274% in local sample L4 while the highest sulphate content SO₃ was 4.301% in local sample L5.
4. References

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