Abstract

Over the past twenty years, considerable research has been conducted to study the microcrack development at the interfaces in concrete. It has been generally established that in normal strength concrete the development of microcracks at the mortar-aggregate interface plays a significant role in the interface deformation and failure behavior of concrete. This paper addresses the role of microcracks in the deformation and failure of concrete and focuses on the development of a new generation of interfaces that would inhibit crack propagation in concrete.

1. Introduction

Failure mechanisms of concrete involve a range of fracture processes, including: (1) crack propagation in aggregate particles, (2) microcracking in the mortar matrix, and (3) debonding of the aggregate from the mortar matrix. The cohesive strength of the mortar matrix plays a critical role in the overall performance of concrete. The development of microcracks at the interfaces in concrete is influenced by the strength and stiffness properties of the matrix, aggregate, and the interface in the material. Therefore, the study of the microcrack development in concrete is crucial for understanding the behavior of concrete under various loading conditions.
3.1 Sandwich specimens

3.2.1 Assessment of interface fracture toughness

Assessment a fracture energy trend of an interface.

where $k = k_1 + k_2$ and $k_1$ is a reference length of which is

$$\gamma = \frac{\text{Ref}(\text{Area})}{\text{Im}(\text{Area})}$$

The press angle $\gamma$ is defined as

The press surface. This fracture energy trend of an interface

where $k_1$ and $k_2$ are the interface stress intensity factors and $\cos(\alpha) = \gamma$.

Consider a semi-infinite free crack lying along an interface between two

2. Basic Interface fracture concepts

with those obtained from testing of a physical laboratory model.

The fracture energy trend of an interface can be expressed in terms of two

Fracture of a sandwich specimen is considered for the assessment of the

and the bond cracking criterion was satisfied.

The bond cracking criterion in which the interface bond property was assumed

Fig. 1. Interface crack configuration
3.2 Testing of Sandwich Specimens

Two types of sandwich specimens presented in Fig. 3 were tested in order to generate the fracture toughness curves of the monolithic aggregate material. The angle of inclination of the central through crack can be achieved by soldering 9o° to the angle of inclination of the central through crack. This was proposed for mixed mode fracture testing of monolithic aggregate. In this paper, the mixed mode fracture testing of monolithic aggregate was used to check the effects of the angle of inclination on the fracture toughness of monolithic aggregate. The specimen mixed mode I-IV mode ratio was considered to be essential in mode I. A sandwiched Brazilian disk can be considered to be essential in mode II. A sandwiched Brazilian disk can be considered to be essential in mode III. This experiment was performed on a polariscope with a sandwiched aggregate layer in the specimen shown in Fig. 3. In order to apply the universal relation given in Eq. (5), the thickness of the aggregate layer should be small compared with the crack width. A four-point bending specimen with a sandwiched aggregate layer is shown in Fig. 3c. To apply the universal relation given in Eq. (5), the thickness y of the aggregate layer should be small compared with the crack width. A four-point bending specimen with a sandwiched aggregate layer is shown in Fig. 3c. To apply the universal relation given in Eq. (5), the thickness y of the aggregate layer should be small compared with the crack width.

Table 1. Mix proportions for the mortar mixes (by weight)

<table>
<thead>
<tr>
<th>Mix</th>
<th>Sand</th>
<th>C+SF</th>
<th>HWPC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0.28</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>4</td>
<td>0.5</td>
<td>0</td>
<td>80</td>
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</tbody>
</table>

Table 2. Mechanical properties for the mortars and granule

<table>
<thead>
<tr>
<th>Mortar</th>
<th>Marshall stability (kPa)</th>
<th>Marshall flow (mm)</th>
<th>Voids (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>92</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>90</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>88</td>
<td>13</td>
<td>2</td>
</tr>
</tbody>
</table>

**Fig. 2. Sandwiched crack model**

**Fig. 3. Two types of sandwich specimens**

(a) Brazilian disk specimen

(b) Four-point bending specimen

The crack size (e) and (f) in the beam specimen was 0.375 mm in the Brazilian disk specimen was 0.25 to 0.5 mm and the relative aggregate layer was 2.5 mm to 2.5 cm. In this test, the aggregate length was 3.5 cm and 2.5 cm. The thickness of the specimen mixed mode I-IV mode ratio was considered to be essential in mode II. A sandwiched Brazilian disk can be considered to be essential in mode III. A sandwiched Brazilian disk can be considered to be essential in mode IV. This experiment was performed on a polariscope with a sandwiched aggregate layer in the specimen shown in Fig. 3c. To apply the universal relation given in Eq. (5), the thickness y of the aggregate layer should be small compared with the crack width. A four-point bending specimen with a sandwiched aggregate layer is shown in Fig. 3c. To apply the universal relation given in Eq. (5), the thickness y of the aggregate layer should be small compared with the crack width. A four-point bending specimen with a sandwiched aggregate layer is shown in Fig. 3c. To apply the universal relation given in Eq. (5), the thickness y of the aggregate layer should be small compared with the crack width.
Fig. 4. Fracture toughness vs fracture angle curve for M/G interface.

Fig. 5. Fracture toughness vs fracture angle curve for M/G interface.

4.1 Crack propagation in interfacial region.

4.2 Crack propagation vs fracture angle curve for M/G interface.

Table 3. Values for two material combinations.

<table>
<thead>
<tr>
<th>Material</th>
<th>Fracture Toughness, $\Gamma$ (J/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granite</td>
<td>0.069</td>
</tr>
<tr>
<td>Marble</td>
<td>0.032</td>
</tr>
</tbody>
</table>
6. Acknowledgement

Considerations such as the effects of the interface on the materials and the behavior of the composite are essential in understanding the performance of the materials. The present approach is based on the idea that the interface is a critical component in the behavior of the composite. The present study, therefore, is an initial step toward understanding the behavior of the interface and how it affects the overall performance of the composite.

5. Conclusion

In this paper, sandwich specimens are used to study the interface behavior of sandwich composites. A new approach for modeling the behavior of the interface is proposed. The proposed approach is applied to the study of the interface behavior in sandwich composites. The results show that the proposed approach is effective in predicting the behavior of the interface.

4.2 Application: Two-Phase Beam Composites

A new model is proposed for the behavior of two-phase beam composites. The model is based on the idea that the behavior of the interface is critical in determining the overall behavior of the composite. The model is validated using experimental data. The model is shown to be effective in predicting the behavior of the composite.

The effect of the interface on the behavior of the composite is studied using experimental data. The results show that the proposed model is effective in predicting the behavior of the composite.

Fig. 4. Crack deflection
References


