

Utilization of Waste Plastic in Manufacturing of Plastic Sand Bricks

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Abstract- *Conventional bricks are the most elementary building materials for houses construction. However, the rapid growth in today's construction industry has obliged the civil engineers in searching for a new building technique that may result in even greater economy, more efficient and durable as an alternative for the conventional brick. Moreover, the high demands for having a speedy and less labour and cost building systems is one of the factor that cause the changes of the masonry conventional systems. These changes have led to improved constructability, performance, and cost as well. Several interlocking bricks has been developed and implemented in building constructions and a number of researches had studied the manufacturing of interlocking brick and its structural behavior as load bearing and non-load bearing element. This technical paper aims to review the development of interlocking brick and its structural behavior. In conclusion, the concept of interlocking system has been widely used as a replacement of the conventional system where it has been utilized either as load bearing or non-load bearing masonry system.*

Key words- *masonry wall; interlocking bricks; structural behavior*

I- INTRODUCTION

Brick masonry is an ancient material and one of the most significant construction materials all over the world. The conventional techniques for bricks making has brought irrefutable drawbacks. The ancient and conventional procedures of brick making were by mixing the raw materials, molding the bricks, and drying and

firing them till they obtain a certain level of strength. However, the manufacturing process of bricks on the last two decades trended to new methods in order to reduce the shortcoming of the ancient methods of making bricks. Due to the current trend within the last two decades, bricks have been developed in different classifications namely solid brick and interlocking brick. The present of interlocking mortar less brick work has prompted a huge increment in field profitability and effectiveness, and also a diminishment in the prerequisites for very particular work teams. Besides, the utilization of interlocking blocks work has increased fast prevalence in numerous outside nations as a contrasting option to traditional blocks for supportable and sustainable buildings. Interlocking blocks are unique in relation to conventional blocks since the absence of the mortar to be filled between the blocks layers during the construction process. In light of this characteristic, the way toward building walls and partitions is speedier and requires less skilled workers as the blocks are assembled dry and stacked on one another. However, there are problems associated with bricks which are low strength, higher water absorption, low fire resistance and high porosity.

Major changes have been occurred to the masonry construction on the last few decades due to the increasing needs of masonry to be competed with other structural materials (e.g. steelwork, concrete). On the other hand, the high demands for having a speedy and less labor and cost building systems is one of the factor that cause the changes of the masonry conventional systems. These changes have led to improved constructability, performance, and cost as well. For that purpose, a few innovative methods, such as surface bond masonry, fiber reinforced polymer wrapping masonry, grouted masonry, and interlocking mortar less masonry have been

developed and utilized for fast and sustainable construction. However, interlocking mortar less system is a new innovative concept to render the masonry construction more economical and faster compared to the conventional masonry construction which has a mortar joints. Therefore, this study aims to review the development of interlocking masonry bricks and blocks from the previous studies as well as the structural behavior.

II- DEVELOPMENT OF INTERLOCKING BRICK

Different types of interlocking blocks and bricks have been produced a mid the previous years, varying in the composition of material, dimension and shape, contingent upon the required strengths and usage. These comprise of “Spar lock system, Meccano system, Sparfil system, Haener system, Putra block system and the Solid Interlocking blocks (SIB) or Hydraform blocks”, which are a change over the conventional bricks and blocks [5]. As reported by Khan and Deshmukh [6] that the various interlocking blocks based on materials are

“soil-cement blocks, rice hush ash cement blocks, and concrete blocks”. The soil cement blocks depend on the soil and cement qualities, the cement-to-soil ratio usually lies between 1:6 and 1:10, by volume while the rice hush ash (RHA) cement blocks, the cement to rice hush ash ratio is 1:4 by volume. Also, for the concrete blocks, the distinctive mix quantity of cement and gravel is 1:5:3. Fayet al.[7] developed a mortar less interlocking soil-cement block for masonry construction. With the appropriate block, the pressing mold was established and samples were adapted in 3 mixtures of soil and cement displaying construction feasibility. In accordance to the related standards, compression resistance, absorption of water and sizing were tested. The results revealed that the absorption of water is the only parameter that mismatched with standards requirements. In Malaysia, Thanonet al.[8] developed interlocking load bearing hollow block system called Putra Block. The blocks are placed on each other and 3D interlocking projections are given in the face of the blocks to incorporate the blocks into masonry systems. 21 different block models have been investigated and analyzed with respect to weight, bearing and shear areas, shape, ease of production, ability to accommodate vertical and horizontal reinforcing stabilizing ties and efficiency of the interlocking mechanism under imposed loads. As a result, the system developed provides a fast, easy and an accurate building system. Also in Malaysia, Abang Ali and Abdul Kadir [9] established other interlocking block (Figure 1), based on the concept of

LEGO. Individual units and identical wall panels have been tested at University. Putra Malaysia under varies type of loading. It has been concluded that the compressive strength of the blocks satisfies the requirements of the Malaysian standards. This innovated block system confirmed to be utilized to construct two storey building with stability and safety.

III- LITERATURE REVIEW

Tangent al.[10] evaluated the residual compressive and shear strengths of novel “coconut-fiber-reinforced-concrete”(CFRC) interlocking blocks under dynamic loading. The study concluded that the CFRC interlocking bricks have sufficient residual capacity after subjection to a dynamic loads and 15 months of storage. Therefore, the structures of CFRC interlocking bricks have the capability to sustain and be utilized continually after any seismic events, if the destruction and harm in blocks are invisible.

Aliet al.[11] investigated the in plane behavior of the mortar less coconut fibre reinforced concrete interlocking blocks structures undergone different dynamic loadings. The contents of coconut fibre were 1% of concrete mass. Four structures elements were prepared (two columns and two walls both with and without coconut fibre rope) and tested under push over, snap back, impact, harmonic and earthquake loadings. It was demonstrated that the bending stiffness and top displacement of the structures with fibre coconut rope were higher than those without rope. At the same time, damping, energy dissipation, and base shear of the structures with rope were smaller than those structures without rope. Therefore, the results confirmed that CFRC interlocking blocks have the potential to be used in regions exposed to any seismic loadings.

Osmanet al.[12] developed an interlocking brick system named Brick cool and then studied the structural behavior of Brick cool walls as load bearing structure. In according to BS3921 and ASTM C67, physical and mechanical tests of the brick unit (specifications, compression strength and absorption of water) were conducted. Randomly 10 bricks unit were picked up and properly cleaned and then undergone the specification test. The bricks were then laid in a row at the same level. The units were then placed in the same level of row. Measurement tape was used to dimension each brick. Some samples were immersed in clean water for twenty four hours where the weight of the samples before and after immersing was recorded in order to determine the water absorption. Compression test of ten interlocking bricks were conducted.

In this study, two specimens of load bearing interlocking Brickool wall dimensioned by 1300 mm in height, 1000 mm in length and 125 mm in width were constructed. The first specimen was prepared with no reinforcement while the second specimen was strengthened with reinforcement of T10mm. Results showed that, the developed brick (Brickool) met the minimum values required by British and American standards and can be used as load bearing with or without reinforcement. However, at the top of the specimens, the failure load of wall specimen with bars has higher value with lower displacement than the wall specimen without bars. At the same time, strengthening the wall by reinforcement result in high compression and tension strain.

Ahmadet al.[13]examined the compressive strength of the wall made of concrete interlocking bricks with mortar and non-mortar paste. Results showed that the compressive strength of concrete interlocking bricks with or without mortar were satisfied the minimum compressive strength required by BS3921:1985 which is 5.2 MPa for the conventional concrete blocks. He concluded that the compressive strength of concrete interlocking bricks with mortar paste is higher than the compressive strength of the conventional concrete blocks. Meanwhile, concrete interlocking bricks increases the compressive strength by 30% when mortar paste was used.

Ahmedet al.[14]investigated the behavior of interlocking masonry walls produced from cement, laterite soil and sand. An experimental tests (physical properties, displacement, and compressive strength) for block units and unreinforced wall panels were carried out under compression load at different eccentricities as illustrated.

Safieet al.[15]investigated experimentally the behavior of mortar less wall specimens made of Putra interlocking blocks. Two different wall specimens (hollow and partially grouted) were constructed with the same sizes of 1000 mm in height, 1200 mm in width and 150 mm in thickness. Both specimens were subjected to lateral load (out-of-plane) with constant pre compression load as shown in Figure 3. Several parameters have been investigated such as carrying capacity of lateral load, mid-height deflection, failure mode, strain characteristic, and the opening of the dry bed joint of the wall panel layers. The study revealed that the structural behavior of the interlocking wall panels under out of plane load were significantly influenced by the pre compression axial load and the rebar. Moreover, the wall panels were categorized as load bearing walls..

Due to the absence of mortar and the filling material between the masonry brick joints, the contact area need to be study with attention. Also, the dry joint behavior is a vital design parameters that must be measured, for this reason only compressibility of dry joint should be investigated. Previous studies have conducted tests to determine the behavior of contact area between brick layers and its effects on the overall behavior of masonry systems. Ayedet al.[17]used an image analysis method. A plain white paper weighing 80 g/m² and free of physical or chemical effect on block has been used. The interface of the interlocking blocks was painted and the white papers between the blocks were placed to print the contact area (Figure 4). An image analysis was developed on MATLAB in order to estimate the percentage of the contact surface printed on the paper. It transformed the image of the printed paper in white and black pixels. Counting of pixels leads to the percentage of the contact area.

Another recent study done by Rekiket al.[18]used Digital Image Correlation method to investigate the compressibility of dry joints. Compressive tests on specimens that cut from Magnesite-Carbon mortar less bricks were carried out. Tests were conducted using a load cell of 200 kN (Figure 5) with an accuracy of 0.2 % of the attained load and 0.0330 mm/minute displacement rate. 2-dimensional digital image correlation was utilized to measure the dry joint behavior under compression.

Jaafaret al.[20]investigated the behavior of the dry joints of interlocking masonry (Figure 7) subjected to axial compression load and consequently their impacts on the structural behavior of prisms made of mortar less interlocking blocks in both grouted and un-grouted. The structural behavior of the contact area between bricks layer (dry joint) were evaluated by conducting single and multiple joints tests with the consideration of geometric imperfections in that faces. The results showed that, geometric imperfections were significantly affected the behavior of the dry bed joint between the brick layers. Varieties of deformation forms were identified in both grouted and un-grouted mortar less interlocking prisms. In the un-grouted prism, the deformation were undertaken place till the applied compression load reaches 0.57 of the max .load. Dry bed joint was mainly affected the deformation of un-grouted prism till the compression load reaches 0.570 of the determined load. However, this behavior was not commonly happened in the early loading of the grouted prisms where it commenced only when 0.380 of the max. load was applied. Furthermore, grouted

IV- METHODOLOGY

prisms achieved high strength and lower deformation compared with the un-grouted prisms.

Moreover, Safieet al.[15] examined the dry joint opening of interlocking mortar less wall subject to out-of-plane load. During testing, the dry joint opening mechanism around mid-height of wall was dominated. The opening was measured by Demec points at several locations along the wall surface. The opening of middle courses of wall increased as lateral load increased for all series of specimens. The total opening may be affected by both lateral load and higher pre-compressive load.

V- CONCLUSION

In conclusion, the interlocking brick developments presented in this study and confirmed that this system is utilized in masonry structures. Accordingly, the concept of interlocking system has been widely used as a replacement of the conventional system. It can be concluded that the shape of the interlocking brick varies with simplicity which result in easy and fast production and assembly in the masonry systems. Moreover, the interlocking mechanism of all the different types of interlocking bricks is sufficient to interlock the assembled bricks in different directions. Based on the researches of the structural behavior of interlocking bricks, it can be concluded that the interlocking blocks have met the minimum specifications and requirements as per British and American Standards. Also, it verified that interlocking brick can be utilized either as load bearing wall or non-load bearing system.

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