

A METHOD AND APPARATUS FOR TESTING DYNAMIC RESPONSE AND IMPACT RESISTANCE OF AN ADHESIVE BASED MATERIAL

FIELD OF INVENTION

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The present invention relates to a method and apparatus for testing dynamic response and impact resistance of an adhesive strength based material for its resistance against repeated low impact energy.

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BACKGROUND ART

Dynamic response and impact resistance test is a methodology taken to measure the adhesion strength of a test specimen subjected to repeated low impact energy.

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Typically, in the dynamic response and impact resistance test, the resistance of the adhesive against adhesion failure or debonding arising from repeated low impact energy caused by a drop ball to induce repeated and low tensile stress along the bonding or adhesive-tile interfaces is determined. Hence, it is a measure of the adhesion bond under a dynamic tensile stress condition. This test may be performed under various conditions to determine the properties of the test specimen. Adhesion testing is specifically undertaken to adhere to industry standards and customer specifications.

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In general, tensile adhesive strength test for cementations adhesives as well as shear strength for dispersion and reaction resin adhesive are based on static test condition. A commonly reported problem is debonding adhesive failure whereby the adhesive suffered from debonding of a tile layer in a tiling system within a period of time after installation. These premature failures can have a significant cost impact.

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The success of a tiling system depends on the initial level of the adhesion bond as well as the ability of the adhesive layer to accommodate various forms of stresses, provided that the adhesive is well applied and the tiles are well laid. Transverse deformation test is useful for classification of adhesives to determine the intrinsic static flexibility of the adhesive by bending. However, the transverse deformation test does not provide the performance of the adhesive in respect to its adhesion with the tile layer and

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compatibility between the tile layer and the bedding adhesive when subjected to dynamic impact load prevailing in service conditions such as traffic loading. Consequently, adhesive failure is observed in tiling systems regardless of adhesive and tile layers, which satisfy the industry standards. Premature failure is observed despite
5 stringent quality control during installation of tiles.

Various other tests are limited to evaluating the performances of adhesive under static conditions and lack coverage for dynamic conditions. Although there are existing simulations for water immersion, heat ageing and freeze thaw cycles, these are
10 subjected to environmental ageing conditions. With the exception of the freeze thaw cycles, water immersion and heat ageing serve to induce degradation of the adhesive and may induce significant interfacial stress between the tile and bedding adhesive.

Thus, with further enhancement, the test methodology and apparatus of the present
15 invention is able to differentiate adhesive that better accommodate stresses arising from impact load through evaluation from a wide range of condition as well as various types of adhesive material.

The subject matter claimed herein is not limited to embodiments that solve any
20 disadvantages or that operate only in environments such as those described above. Rather, this background is only provided to illustrate one exemplary technology area where some embodiments described herein may be practice.

SUMMARY OF INVENTION

In one embodiment of the present invention is a method for testing dynamic response and impact resistance of an adhesive based material on a test specimen prepared by lap-bonding a first surface of the test specimen to a second surface of the test specimen using the adhesive and clamping the first surface to an apparatus. The method comprising the steps of inducing a cyclic drop of a load with a predetermined mass from a predetermined height onto the test specimen, tracking an iteration value of the cyclic drop and detecting a debonding failure of the test specimen through a tracking mechanism wherein inducing the cyclic drop of the load with the predetermined mass from the predetermined height onto the test specimen further comprises the steps of receiving the load through a conveyor mechanism, releasing the load from the predetermined height to free fall onto the test specimen; retrieving the load through the conveyor mechanism and allowing free falling of the load from the said height of the test specimen until the debonding failure occurs.

In another embodiment of the present invention is an apparatus for testing dynamic response and impact resistance of an adhesive based material on a test specimen prepared by lap-bonding a first surface of the test specimen to a second surface of the test specimen using the adhesive and clamping the first surface to the apparatus. The apparatus comprises a conveyor mechanism, a counter mechanism, a tracking mechanism and a conduit. The conveyor mechanism comprises means for inducing a cyclic drop of a load with a predetermined mass from a predetermined height onto the test specimen. The counter mechanism comprises means for tracking an iteration value of the cyclic drop. The tracking mechanism comprises means for detecting a debonding failure of the test specimen and the conduit comprises means for allowing free falling of the load from the said height of the test specimen until the debonding failure occurs. The conveyor mechanism further comprises means for receiving the load, releasing the load from the predetermined height to free fall onto the test specimen and retrieving the load.

The present invention consists of several novel features and a combination of parts hereinafter fully described and illustrated in the accompanying drawings, it being understood that various changes in the details may be made without departing from the scope of the invention or sacrificing any of the advantages of the present invention.

BRIEF DESCRIPTION OF ACCOMPANYING DRAWINGS

To further clarify various aspects of some embodiments of the present invention, a more particular description of the invention will be rendered by references to specific
5 embodiments thereof, which are illustrated, in the appended drawings. It is appreciated that these drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope. The invention will be described and explained with additional specificity and detail through the accompanying drawings in which:

10 FIG. 1A illustrates an apparatus arrangement for testing dynamic response and impact resistance of an adhesive based material on a test specimen.

FIG. 1B illustrates an apparatus setup for testing dynamic response and impact
15 resistance of an adhesive based material on a test specimen.

FIG. 2 is a flowchart illustrating a method for testing dynamic response and impact
20 resistance of an adhesive based material on a test specimen.

FIG. 3 is a flowchart illustrating a method for dropping a load with a predetermined mass
25 from a predetermined height onto a test specimen.

FIG. 4 is a flowchart illustrating a method for retrieving the load through a conveyor
mechanism.

25 FIG. 5 is a flowchart illustrating a method for detecting adhesion failure of the test specimen through a tracking mechanism.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the invention relate to a method and apparatus for testing dynamic response and impact resistance of an adhesive based material. Hereinafter, this specification will describe the present invention according to the preferred embodiments of the present invention. However, it is to be understood that limiting the description to the preferred embodiments of the invention is merely to facilitate discussion of the present invention and it is envisioned without departing from the scope of the appended claims.

The present invention describes a method and an apparatus that is capable of testing dynamic response and impact resistance of an adhesive based material by lap-bonding a first surface of a test specimen to a second surface of the test specimen using different types of adhesives and clamping the first surface to the test apparatus.

Reference is first being made to FIGs. 1A and 1B collectively. FIG. 1A illustrates an apparatus arrangement for testing dynamic response and impact resistance of an adhesive based material on a test specimen while FIG. 1B illustrates an apparatus setup for testing dynamic response and impact resistance of adhesive based material on a test specimen. The apparatus arrangement for testing impact resistance of an adhesive based material such as cement-based adhesives comprises a conveyor mechanism (102), a conduit (104), a test specimen (106), a tracking mechanism (108) and a counter mechanism (110).

The apparatus is driven by an alternating current gear motor (1), which utilizes the combination of electric energy and magnetic current. Thus fuel is not required to operate the motor, as found with many engines. A motor speed controller (9) controls the speed of the alternating current gear motor (1). The speed of the motor speed controller (9) is dependent on the average voltage sent to the alternating current gear motor (1). This is transparent to a user as it is generated automatically and pre-programmed as the user will only observe the average effect of the speed is observed.

A programmable logic controller (2), which is a microprocessor-based system, is used to automate the electromechanical process of the apparatus. The programmable logic

controller (2) enables multiple input and output arrangement to control operation of the apparatus. The apparatus is operated through a start button (5), stop button (6) and a reset button (7). These buttons are pre-programmed in the programmable logic controller (2) such that when the start button is depressed, the test is executed continuously until a debonding failure is detected by the tracking mechanism (108) and the operation automatically terminates. Both the stop button (6) and reset button (7) are for manual operation of the apparatus. The operation of the entire test may be terminated manually by depressing the stop button (5) and the reset button (7).

The counter mechanism (110) may comprise of a digital counter (8), which is used to track the number of counts of the load, which is dropped, to the test specimen until debonding failure is detected. The need to utilize the reset button (7) arises when there is a need to restart the entire test. Once the reset button (7) is depressed, indicating the test to be restarted, the digital counter (8) will automatically be reset to the programmed starting point which could be zero for most condition and the count of drops repeats through a continuous cycle.

The conduit (104) could be a vertical conduit implemented against the test specimen (106) or it may be horizontally inclined with a bend portion at the edge of the inclined conduit. The conduit may comprise of a transparent acrylic tube (10). The load of a predetermined mass will be dropped from a predetermined height through the conduit (104) onto the test specimen (106). The mass of the drop load and the drop height is determined based on the type and thickness of the test specimen (106). By predetermining mass or height, it is meant that a person skilled in the art will be able to ascertain the mass or height suitable for an effective testing parameter.

The test specimen (106) comprises either ceramic or stone tiles which is subjected to regular dynamic or impact load. The test specimen (106) of either ceramic or stone tile type is clamped to the apparatus using a toggle clamp for tile (3) affixed to the apparatus. The toggle clamp for tile (3) has a limited clamping range. This is such that excessive force is not incurred onto the surfaces of the test specimens specifically tiles, which may cause failure due to external factors not impacted, by the mass of the drop load.

Tracking mechanism (108) of the testing apparatus is embedded at close proximity to the test specimen. The tracking mechanism (108) may comprise of an electronic trigger switch connected to a counter or an electronic counter-countermeasure device such as a sensor with a built in counter. The tracking mechanism (108) is connected to the programmable logic controller (2). The programmable logic controller (2) automatically produces the tracked response when debonding failure occurs. The programmable logic controller (2) accepts the tracked response from tracking mechanism such as a sensor and processes that response by making decisions in accordance with a stored program in the controller. The programmable logic controller (2) thereafter generates an automatic output to the apparatus to perform a particular function based on the application. The operation is terminated based on the generated output of the tracked response when a debonding failure is detected. The test cycle is repeated continuously when debonding failure is not detected by the tracking mechanism (108).

15 The conveyor mechanism (102) of the testing apparatus may comprise of a magnet (4) for lifting the drop load or a belt over roller conveyor, which is desired for an incline or decline situation, a chain conveyor or a robotic arm conveyor. The magnetic conveyor (4) for lifting a drop load provides effective control of ferrous objects such as ball bearing. Magnetic conveyor utilizes magnets to create the motion necessary for lifting the drop load. A retainer such as a ball bearing retainer (11) would retain the dropped load for instance ball bearing when it is dropped from a predetermined height. The conveyor mechanism (102) may be substituted with a mechanical catch such as a compression catch. Alternatively, the testing apparatus may be manually operated wherein the drop load is manually picked up after hitting the test specimen and thereafter the said drop load is dropped from a predetermined height in a cyclic condition to achieve the same test condition as above.

Reference is now being made to FIG. 2. FIG. 2 is a flowchart illustrating a method for testing dynamic response and impact resistance of an adhesive based material on a test specimen. The method (200) for testing dynamic response and impact resistance of an adhesive based material on a test specimen prepared by lap-bonding a first surface of the test specimen to a second surface of the test specimen using the adhesive and clamping the first surface to an apparatus, the method (200) comprising the steps of inducing a cyclic drop of a load with a predetermined mass from a predetermined height

onto the test specimen (202), tracking an iteration value of the cyclic drop (204) and detecting a debonding failure of the test specimen through a tracking mechanism (206) wherein inducing the cyclic drop of the load with the predetermined mass from the predetermined height onto the test specimen (202) further comprises the steps of
 5 receiving the load through a conveyor mechanism (302), releasing the load from the predetermined height to free fall onto the test specimen (304), retrieving the load through the conveyor mechanism (306) and allowing free falling of the load from the said height of the test specimen until the debonding failure occurs (308).

10 The principle of the test methodology subjects the test specimen specifically the tile adhesive and the bonding surfaces to tensile impact load to simulate service load condition arising mainly from traffic such as foot and light vehicular movement. This is achieved through a cyclic impact of continuous load drop onto the back surface of the extended lap-bonded test specimen until debonding failure occurs.

15 The test is an approach to determine the resistance of tile layers bonded to a tile adhesive against debonding failure from dynamic adhesion stresses introduced by a continuous impact load. The test comprises of two pieces of tiles, the back surface of the first piece of tile is lap-bonded to the top surface of the second piece of tile using
 20 different adhesives. One of the exposed ends of the first surface of the first piece of tile is rigidly clamped whilst the other end is subjected to an impact load. The resulting energy of impact is computed from the mass of the load over a predetermined height, which will be prescribed for different tiling systems according to the type of tile, adhesive and method of installing the test specimen to the test apparatus. The impact energy
 25 induced onto the back surface of the exposed end of the lap-bonded test specimen results in dynamic adhesion stress between the tiles and the adhesive interfaces. The performance of the adhesive type as well as the robustness of the test specimen is determined by the number of the cyclic impact of the continuous load drop, which causes debonding failure.

30 Reference is now being made to FIGs. 3 and 4 collectively. FIG. 3 is a flowchart that illustrates the method for dropping a load with a predetermined mass over a predetermined height onto an adhesive bonded test specimen while FIG. 4 is a flowchart that illustrates a method for retrieving the load through a conveyor mechanism. The load

with a predetermined mass dropped over a predetermined height comprises the steps of receiving the load through a conveyor mechanism (302). Thereafter, the load is release from the predetermined height to free-fall onto the test specimen (304). The dropped load is retrieved through the conveyor mechanism (306). The dropped load is allowed to fall freely from the predetermined height onto the test specimen until debonding failure is detected on the test specimen (308). The dropped load, which hits the adhesive bonded test specimen will be collected (402) and automatically be conveyed onto the conveyor mechanism (404).

Reference is now being made to FIG. 5. FIG. 5 is a flowchart illustrating a method for detecting adhesion failure of the test specimen through a tracking mechanism. The adhesion failure of the adhesive bonded test specimen is an effect of the load being dropped continuously over a repetitive cycle is detected through a tracking mechanism. The said tracking mechanism, which comprises of an electronic trigger switch or a sensor will sense and verify the condition of the adhesive bonded test specimen (502). The drop test would be terminated (506) and the number of cyclic iteration of load drop would be recorded to determine the failure point of the test specimen (508) when an adhesion failure is observed on the adhesive bonded test specimen.

The success of the test specimen specifically the tiling system depends on the initial level of the adhesion bond as well as the ability of the adhesive layer to accommodate various stresses with the adhesive well intact and the tiles well laid for test specimen of tile type.

The apparatus and methodology of the test is useful in evaluating the compatibility between the bedding adhesive and tile layer. It is known that debonding failure may occur due to the poor compatibility between the layers of the first and second surface of the tile, which is prevalent in a laminated structured system. The approach taken in the present invention is far more susceptible to determine the quality and robustness of different adhesive types. Moreover, the electric driven apparatus is a preferred choice instead of fuel engines for the reason that the same is cleaner and less expensive to operate.

The present invention may be embodied in other specific forms without departing from its essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore indicated by the appended claims rather than by the foregoing description. All changes,
5 which come within the meaning and range of equivalency of the claims, are to be embraced within their scope.

CLAIMS

1. A method (200) for testing dynamic response and impact resistance of an adhesive based material on a test specimen prepared by lap-bonding a first surface of the test specimen to a second surface of the test specimen using the adhesive and clamping the first surface to an apparatus, the method (200) comprising the steps of:

inducing a cyclic drop of a load with a predetermined mass from a predetermined height onto the test specimen (202);

tracking an iteration value of the cyclic drop (204); and

detecting a debonding failure of the test specimen through a tracking mechanism (206);

wherein inducing the cyclic drop of the load with the predetermined mass from the predetermined height onto the test specimen (202) further

comprises the steps of:

receiving the load through a conveyor mechanism (302);

releasing the load from the predetermined height to free fall onto the test specimen (304);

retrieving the load through the conveyor mechanism (306); and

allowing free falling of the load from the said height of the test specimen until the debonding failure occurs (308).

2. The method according to claim 1, wherein retrieving the load through a conveyor mechanism (206) further comprises the steps of:

collecting the load which hits the test specimen (402); and

transporting the load back into the conveyor mechanism (404).

3. The method according to claim 1, wherein detecting the debonding failure of the test specimen through the tracking mechanism (208) further comprises the steps of:

verifying the test specimen (502); and

if the debonding failure is observed on the test specimen;

terminating the cyclic drop (506); and

recording the iteration value to determine a failure point (508).

4. The method according to claim 1, wherein tracking an iteration value of the cyclic drop (202) further comprises incrementing the iteration value until the debonding failure occurs.

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5. The method according to claim 1, wherein the conveyor mechanism (102), comprise of a magnetic conveyor, a belt over roller conveyor which is desired for an incline and decline situation, a chain conveyor or a mechanical catch.

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6. The method according to claim 1, wherein the tracking mechanism (108), which is embedded at close proximity to the test specimen comprises of an electromagnetic sensor such as an electronic trigger switch connected to a counter or an electronic counter-countermeasure device such as a sensor with a built in counter.

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7. An apparatus (100) for testing dynamic response and impact resistance of an adhesive based material on a test specimen (106) prepared by lap-bonding a first surface of the test specimen (106) to a second surface of the test specimen (106) using the adhesive and clamping the first surface to the apparatus (100), the apparatus (100) comprising:

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a conveyor mechanism (102);
a counter mechanism (110);
a tracking mechanism (108); and
a conduit (104)

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characterized in that

the conveyor mechanism (102) comprises means for inducing a cyclic drop of a load with a predetermined mass from a predetermined height onto the test specimen (106);

the counter mechanism (110) comprises means for tracking an iteration value of the cyclic drop;

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the tracking mechanism (108) comprises means for detecting a debonding failure of the test specimen (106); and

the conduit (104) comprises means for allowing free falling of the load from the said height of the test specimen (106) until the debonding failure occurs.

further characterized in that the conveyor mechanism (102) comprises means for

receiving the load;

releasing the load from the predetermined height to free fall onto the test specimen (106); and

retrieving the load.

8. The apparatus according to claim 7, wherein the conveyor mechanism (102) further comprises means for:

collecting the load which hits the test specimen (106); and

transporting the load back into the conveyor mechanism (102)..

9. The apparatus according to claim 7, wherein the tracking mechanism (108) further comprises means for:

verifying the test specimen (106); and

if the debonding failure is observed on the test specimen (106);

terminating the cyclic drop; and

recording the iteration value to determine a failure point.

10. The apparatus according to claim 7, wherein the counter mechanism (110) further comprises means for incrementing the iteration value until the debonding failure occurs.

11. The apparatus according to claim 7, wherein the conveyor mechanism (102), comprise of a magnetic conveyor, a belt over roller conveyor which is desired for an incline and decline situation, a chain conveyor or a mechanical catch.

12. The apparatus according to claim 7, wherein the tracking mechanism (108), which is embedded at close proximity to the test specimen comprises of an electromagnetic sensor such as an electronic trigger switch connected to a

counter or an electronic counter-countermeasure device such as a sensor with a built in counter.