Development of multifunctional tiling defect detector tool

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Abstract. The Multifunctional Tiling Defect Detector Tool (MT2DT) was successfully developed as an innovative tool that could be used in inspecting tiles that have less cement compression to prevent the tile from cracking in the future. The aims of this research were firstly to compare the conventional method with MT2DT over some time and secondly to identify consumers' satisfaction with MT2DT as an innovative product. MT2DT was successfully installed by using main components like steel bearing balls, hollow steel, and adjustable rods. This product was also successfully run to investigate the problematic tiles compared to conventional methods. The questionnaires were divided into five (5) sections about satisfaction and they were answered by consumers who run the product technically. As a result, this innovation project has been enhanced and changed to make it simpler for customers to do tile inspection work. With the use of this device, someone can identify tiles with less cement compression and save them from cracking in the future in less time compared to conventional tools. Besides, the MT2DT showed high satisfaction among consumers with the mean average was 4.80. It showed MT2DT could help them, particularly first-time homebuyers, identify flaws as soon as possible during the liability period.

1 Introduction

Typically, inspecting the floor tiles is one of the tasks that must be completed when unpacking a new house or a structure to find any kind of defections. There are several types of floor inspection, including using bare hands or coins. The most common way to check floor tiles is with your bare hands, which are knuckles, but this can be hazardous because your knuckle could get hurt while knocking the tiles and it could also hurt your back since you must bend down to move from one tile to another [1]. Additionally, imagine if many tiles need to be checked, it will take more time and energy, as time and energy are both important from an engineering standpoint [2]. Industries need a very helpful tool, especially for non-technical people to inspect the tiles, it is also easy to use because you only need to pull or push to inspect the house tiles and can reach a high and narrow place in the house area. For safety, the tool can reduce the risk of back pain like previous examination methods that harm the back of the body, especially the waist. Every year, the conventional tile inspection used by professional workers in the construction sector is seen to be another difficult problem in checking the density of the mortar. For the conventional method, tile inspection uses bare

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hands (knuckles), a coin, and a tapping rod. The selection of these three methods depends on the individual who inspects but it has a detrimental effect on the user because the user must stoop down to check the installed tile [3]. Furthermore, it also takes a long time to check the tiles in one part, and depending on the size of the tiles if the size of the tiles is quite large then a long time will be needed to check the tiles. A tapping rod is a tool that is widely used by artisans, this is because of its efficient way of using it compared to bare hands and coins. A tapping rod is also a tool that is the reason for our product because the concept is the same but the way of working is different each tool also has its advantages and depends on the user in checking the tiles that have been installed [4].

1.1 Problem statement

Generally, tile defects are the most common problem and are often experienced by homeowners. One of the major causes of the failure of the tiling system is poor workmanship, particularly incomplete bedding of the tiles in the adhesive [1]. Some common causes for tile defects are tile defects that occur because of improper installation techniques or materials unsuitable for tile surfaces [3]. Tile defects also arise due to reasons like uneven floors, improper cleaning, uneven grout joints, poor adhesion, poor quality adhesive, etc. The effects of tile defects in terms of losses are homeowner must re-incur the costs to replace the defective tile because the cost of replacing a defective tile is relatively high when the liability period (Defect Liability Period) has expired. The Defect Liability Period is defined as the period from the date you receive delivery of vacant possession and keys to your property, where the developer is responsible for fixing any defects [4]. The duration of the liability period is 24 months from the date that you receive the keys.

1.2 Objectives

Several objectives or goals need to be achieved to ensure that the research conducted is successful:

1. To identify the effectiveness of the Multifunctional Tiling Defect Detector Tool between the conventional method in terms of time inspection.
2. To identify consumer satisfaction with MT2DT as an innovative product.

2 Literature review

In the past, most people would tap a coin on each tile to check the arrangement of the tiles, and some tile contractors used their knuckles to inspect their tiles. This requires a great amount of time and work. A tapping rod is a common tool for determining hollowness. To assess the scope of the hollow wall, lightly touch the wall using a tapping rod [5]. Tile distress may take many different forms. However, two of the most concerning are cases of tiles that have broken and cracked due to impact damage, as well as those that have become completely removed from their background. The common sight of cracked and broken tiles, as well as bare patches where tiles are missing, must cause the general public and professional construction workers or skilled workers to be overly worried about the possible durability of applied tile coatings [6]. When investigating the sources of tiling distress or carrying out repairs, it is often evident that the tile installer's inability to achieve adequate contact coverage of the bedding adhesive to the back of the tiles has contributed to the problem. In many situations, it is decided that the tiling would not be in distress if it had been properly bedded, or even near to entirely bedded. It appears likely that a tile kept in place with 50% adhesive contact coverage can only withstand roughly half the amount of differential

movement stress as a tile with 100% contact coverage [7]. This is confirmed by studies that demonstrate an increase in bond strength is generally equal to an increment in contact coverage. A tile with close to 100% contact coverage is also less likely to sustain impact damage since there are no large gaps to allow localized deflection when impact occurs. As a result, improper tile installation techniques that leave voids behind tiles contribute considerably to the level of fracture and impact damage occurring to tiling globally. It is fair and reasonable to state that upgrading tile installation techniques to reach 100% adhesive coverage will contribute to the reduction of distress in finished tiling projects [8].

Generally, tile detectors are important to facilitate the work of inspecting installed floors and could help to reduce the risk of back pain. The consumers need the tools adjustable and have various functions. Specifically, having a pocket to store carpentry items, a magnet to attract the metal scrap left during the construction or installation process, and finally, it can check the hollowness of the tiles that have been installed through the sound produced when it moves on the surface of the tile [9].

3 Methodology

It's a research strategy that allows us to get qualitative and quantitative data about potential consumer consumption/usage patterns, preferences, and responses to a product. The product development testing process guarantees that the product performs as expected. This phase begins once the product requirements have been achieved. Testing will take place at various points during the project, depending on the development techniques utilized. The purpose is to identify all conceivable scenarios that the developer may have neglected.

The Multifunctional Tiling Defect Detector Tool is developed according to the technical design of researchers. This product is a unique piece of equipment with a technical manual that helps to apply it to inspect the tile sound and compactness on the floor without taking too much time. This product is also suited for both small and big areas of tile and works best for 4 (four) square meters of tile and above. This tool is mainly targeted at construction workers, contractors, and new house buyers.

The materials are hollow steel rods, used as a steel bearing ball holder to be soldered or welded together with wheel bearings, we used steel bearing balls to produce a ‘thump’ sound to indicate when it meets a preinstalled tile to detect the density of mortar from the sound produced through contact between the steel bearing ball and the tile [3,4]. Next, we’re using wheel bearings to help the installed steel bearing balls roll or move around the tile surface furthermore we also use hollow steel rods as a connector for the mop rod, steel bearing balls, and bearing wheel. Besides we’re using hollow steel which is 2×3 in size as a pocket for this innovation tool. Overall, Multifunctional MT2DT) is an innovative product that can detect tile defects quickly through the sound produced by the tile as the product rolls on it. MT2DT also has various functions such as having a provided pocket to store the equipment used for the two (2) tiles inspection process such as bubble level and a measuring tape and has a magnet for gathering metal scrap after the construction work process.

Steel Bearing Balls Steel bearing balls are used to produce sound when they come in contact with the installed tile, this steel bearing ball is attached to a hollow steel rod that connects to the wheel bearing and will roll if pushed or pulled by the user. The choice of this material is because it is made of steel and only needs to be welded with other parts to realize this innovation. Hollow Steel (2x3) is used to produce pockets for MT2DT because of its size which is not too big it is also mostly used by contractors or developers to build houses or buildings so it is quite easy to get this material and not only that, this material is also the same as that other that is only need welding only with other materials to realize this innovation. Adjustable Rod is chosen because it is light and adjustable which can help users use it in high and narrow places not only that, the mop rod is also chosen because it can be carried

anywhere because it is light and easy to process. Steel Rod Steel rod is used to connect sliding gate roller with steel bearing balls, this material also has the desired characteristics of light and is not easy to rust. In addition, it is also easy to process produce innovations that will be produced and it is easy to find in any tool store and steel material shops. Sliding Gate Roller Sliding gate roller is a material that is no longer foreign to our daily routine because it is found on the sliding gate & grill. our innovation is one of the important materials because it will cause steel balls that are welded together with steel rods and will eventually produce noise when it comes in contact with the tile that has been installed to check the density of mortar in the tiles. Magnet Welding magnets are tools used to temporarily hold and assemble joints using magnetic force during welding and assembly work. It may be used as a hinge for thin plates, as a base for marking, or for setting an angle.

Besides, to identify consumer satisfaction with MT2DT as an innovative product, a set of questionnaires was provided and were given to a total number of 15 respondents who were involved in civil works in Politeknik Kuching Sarawak from March 2022 to May 2023. The set of improvised questionnaires about the satisfaction of the product includes a combination of items about MT2DT such as quality, durability, product effectiveness, speed of work process, and ergonomics control. The data was collected from 15 respondents who are mostly in the work field of civil engineering sectors with the Likert Scale referred to as 5 – Excellent, 4 – Good, 3 – Fair, 2 – Poor, and 1 - Very poor [9]. For product review, researchers created an evaluation form on Google Forms and sent it to respondents, the majority of whom worked in the sectors of Civil Engineering, Building Technology, and Home Renovation.

A questionnaire is a research instrument that consists of a series of questions that are used to gather data from respondents. These instruments use an interview-style structure and include either written or oral questions. To stimulate respondents' interest, the questionnaire should focus on a topic that is significant or significant. It should only look for information that cannot be found elsewhere. It should be as brief as possible while being thorough. Open-ended, closed-ended, or a combination of open-ended and closed-ended questions are frequent in questionnaires. This allows us to collect both qualitative and quantitative data, depending on the respondent's requirements.

In short, Figure 1 shows the flowchart of the research methodology throughout this project.

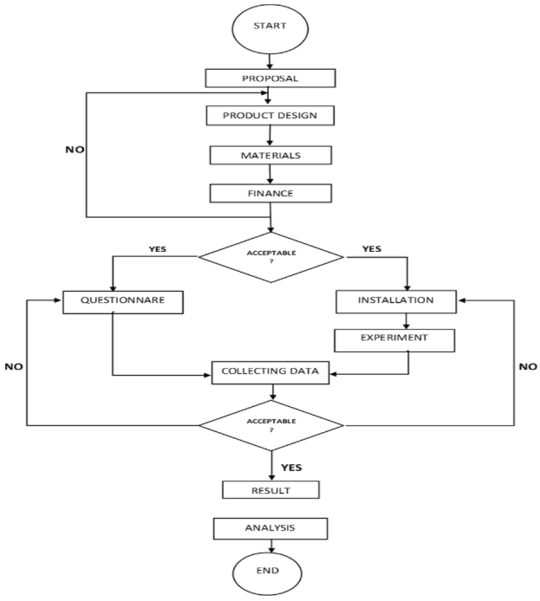

Fig. 1. Flowchart of the research methodology.

4 Finding and analysis

Fig. 2. The outcome of MT2DT.

Figure 2 shows the outcome of MT2DT. The technical instructions are given in the MT2DT manual. In short, consumers could handle the product with easy motion. Table 1.0 shows time comparison data for the time taken to inspect floor tiles with a different method. For data tester 1, it took 19 seconds to inspect the floor tiles by using a bare hand while using coins 20.1 seconds, but it only took 10 seconds to use the Multifunctional Tiling Defect Detector Tool to inspect 10 floor tiles. Meanwhile, for data tester 2, it took 38.8 seconds to inspect the floor tiles by using a bare hand while using coins 43.7 seconds, but it only took 14 seconds by using the Multifunctional Tiling Defect Detector Tool. Next, for data tester 3, it took 26.9 seconds to inspect the floor tiles by using a bare hand while using coins 26 seconds, but it only took 12.2 seconds by using the Multifunctional Tiling Defect Detector Tool. As a result, the Multifunctional Tiling Defect Detector Tool (MT2DT) took the least amount of time for floor inspection compared to the conventional methods.

Table 1. Time comparison data using a different method in inspecting floor tiles.

Method	Time is taken to inspect floor tiles (s)		
	Tester 1	**Tester 2**	**Tester 3**
Bare hand (Knuckle)	19	38.8	26.9
Using coins	20.1	43.7	26
MT2DT	10	14	12.2
Total tiles: 10 (Size 1 ft x 1 ft)			

Besides, the data was collected from 15 respondents who are mostly in the work field of civil engineering sectors. The points referred to as 5 – Excellent, 4 – Good, 3 – Fair, 2 – Poor, and 1 - Very poor as shown in Table 2, there were 12 respondents rated (5) Excellent and 3 respondents rated (4) Good. The estimated mean for Product Quality is 4.8, classified as Excellent. For the durability of the Product, 14 respondents rated (5) Excellent, and 1 respondent rated (4) Good. The estimated mean Durability of the product is 4.93, classified as Excellent. For Product Effectiveness, 12 respondents rated (5) Excellent, 2 respondents rated (4) Good, and 1 respondent rated (3) Fair. The estimated mean for Product Effectiveness is 4.73, classified as Excellent. For the Speed of Work Process, 12 respondents rated (5) Excellent, and 3 respondents rated (4) Good. The estimated mean for the Speed of the Work

Process is 4.8, classified as Excellent. For Ergonomics,13 respondents rated (5) Excellent, and 2 respondents rated (4) Good. The estimated mean Ergonomic is 4.86, classified as Excellent. As a result, the average mean for product satisfaction obtained is 4.8 and classified as Excellent.

Table 2. Likert scale on consumer satisfaction using MT2DT.

Item	5	4	3	2	1	Total	Mean
Quality of the product	12	3	0	0	0	15	4.80
Durability o of the product	14	1	0	0	0	15	4.93
Product Effectiveness	12	2	0	0	0	15	4.73
Speed of word process	12	3	0	0	0	15	4.80
Ergonomics control	13	2	0	0	0	15	4.86

Mean average = 4.80 (Excellent)

5 Conclusion

Researchers were able to accomplish all goals firstly by demonstrating/ inspecting and secondly via distributing surveys to knowledgeable contractors and responders who mostly work in the civil engineering industry. Many people concurred that MT2DT helped them speed up the inspection process by helping them swiftly examine floor tiles. This demonstrates how highly recognized and valued MT2DT is as an innovative product. This innovation is also very helpful, especially for non-technical people to inspect the tiles, it is also easy to use because you only need to pull or push to inspect the house tiles and can reach a high and narrow place in the house area.

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