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a study of using technology acceptance model and its effect on improving road pavement smoothness in taiwan   
  
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abstract   
using the technology acceptance model (tam) as its theoretical foundation, this study intends to explore the use of travelling beam devices in road engineerings in taiwan and offer suggestions based on its findings to encourage industry willingness for device deployment resulting in improving road pavement smoothness in taiwan. the study subjects were pavement smoothness device operators in taiwan. a total of 107 valid questionnaires were returned. the questionnaire results were analyzed using descriptive statistics, confirmatory factor analysis and structural equation modeling. study results show that more training/support and perceived ease of use can lead to more willingness to use travelling beam devices and consequentially help improve pavement smoothness. structural equation modeling (sem) analysis results also indicate training/support, perceived ease of use and attitude will give users’ positive attitudes towards use of travelling beam devices.   
  
keywords: technology acceptance model (tam); pavement smoothness; profilograph devices; confirmatory factor analysis (cfa); structural equation modeling (sem)   
  
introduction   
  
pavement smoothness can ensure not only a more comfortable driving experience but also   
  
longer road life cycles. during the rapid economic growth in taiwan over the past years,   
  
road engineering has become a type of public works that are closely and directly related to   
  
the lives of road user, through construction of new roads, renovation, widening, or   
  
pipeline/wire installation. roads are also the arteries of economic development. poor   
  
smoothness in road surfaces poses a threat to transportation safety, increases transportation   
  
costs and vehicle maintenance/repair costs.   
  
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state of the literature   
  
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the related literature used instrument equipment to investigate the smoothness of pavement.   
  
however, few studied have been carried out on the safety of both pedestrians and drivers for   
  
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this issue.   
  
three types of equipment were used for pavement smoothness detection (e.g. haas, et al.,   
  
1994; shambhavi co., 2003). but the lack of studies for equipment operator behavior affect the   
  
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detected results’ validity.   
  
equipment operator behavior is an important proper essential of the pavement smoothness   
  
devices (e.g. joao et al., 2010; losa & leandri, 2011). these studies should be investigated for the effect of the tam model on pavement smoothness detection.   
  
contribution of this paper to the literature   
  
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the main contribution of this paper to the literature is related to how the tam model   
  
influences training/support the respondents’ willingness to use the devices during the   
  
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pavement smoothness detection.   
  
using sem analysis of the tam model product, users enhance their willingness to use the   
  
  
  
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pavement smoothness devices.   
  
since the tam model is used to analyze connections among users’ attitudes and willingness   
  
(ong, et al., 2004), this study can be used to teach road engineering about the devices during pavement smoothness detection.   
  
the smoothness properties of pavement are subject to the influences of temperature, precipitation, and traffic flow; therefore, high-quality road pavement work is key to driving safety (ongel, et al., 2009). as people are more aware of the importance of their rights and safety, it is an urgent priority to ensure smooth and enduring road pavement. according to a national cooperative high research program report on 200 roads in 10 states in the us, a 50% increase in pavement smoothness can result in an extension of at least 15% of the road lifespan. this indicates smooth pavement increases road lifespans.   
  
currently, pavement smoothness is measured with the international roughness index (iri). the iri has become a standard tool for measuring the comfort level one experiences when walking or driving on a road. however, kim et al. (2007) used finite-element modeling (fem) to investigate the smoothness of concrete pavement and they found the iri unable to represent the slab curvatures caused by temperature differences between the top and bottom of the pavements. in addition, many researchers and experts have developed several methods and tools to measure pavement smoothness. for example, harris et al. (2010) used novel algorithms to measure pavement profile height and found only a 2% discrepancy between their calculation results and iri values. the state governments of florida, texas and new york directly use astm e950 or aashto pp49 standards to compare and evaluate pavement profile height data. lin et al. (2004) used the least square inversion technique to calculate dielectric constants and found the constants in inverse proportion to the pavement   
  
2182   
  
  
  
  
  
eurasia j math sci and tech ed   
  
roughness. based on their findings, it can be said that dielectric constants can be used to evaluate pavement roughness or smoothness. joao et al. (2010) used the scanning prototype machine to achieve 3d characterization of pavement texture and profile depth. losa and leandri (2011) applied butterworth's numerical filters and moving average filters to analyzing pavement texture depths. wang and li (2011) built a model that can effectively predict pavement smoothness based on the integration of the gray theory with fuzzy regression analysis.   
  
according to carry et al. (1960), aashto test results indicate pavement smoothness contributes 95% of road serviceability. the most direct method to quantify pavement smoothness is to place the travelling beam device at a point of the pavement and then measure the height difference at the point or calculate the standard deviation of pavement smoothness. currently, a comprehensive acceptance review mechanism has been gradually introduced into road construction in the us, mainly using the international roughness index (iri) or the profile index (pi) for the measurement of pavement smoothness. different states in the us are now using different types of travelling beam devices to measure pavement smoothness. for example, in washington state, the department of transportation (wsdot) distress data collection vans are used to measure pavement smoothness.   
  
currently, there are mainly three types of equipment for pavement smoothness (or roughness) measurement: road profilers, profilographs, and response-type devices. (haas, et al., 1994). in astm e950, it is explicitly stipulated that, after the road pavement is completed, pavement smoothness measurement must be conducted as part of the standard acceptance review procedure. the three types of travelling beam devices most commonly seen are high-low detectors, inertial profilers, and three-meter straight edges. high-low detectors consist of double wheel trailers that are towed by operators. the wheel mounted on the trailer was supported by leaf springs. altitude variations in the pavement surface cause the wheels to move with respect to the frame of the device. a three-meter straight edge approximately 3 meters in length may be used to determine lateral surface regularity of a pavement surface. this lightweight device is equally supported at both ends producing a set height between the pavement surfaces (shambhavi co., 2003).   
  
however, since the measuring devices are operated by users, anthropogenic factors such as differences in personal willingness to use the devices or knowledge about the devices or the acceptance review standard functions can result in differences or even errors in the smoothness calculation, which in turn may lead to traffic accidents and damage claims caused by poor pavement smoothness. for example, in taiwan, there were 16 deaths and 125 injuries in traffic accidents caused by rough pavements from 2005 to 2007 and consequentially 211 damage claims for official tort compensation (worth nt$ 64 million), accounting for 38% of the total amount of claims for national tort compensation during the same time period. in 2008, the public construction commission of the executive yuan conducted a survey on the pavement smoothness of the roads in each city and county in taiwan and found only 13% of the surveyed roads had acceptable smoothness levels. this   
  
2183   
  
  
  
  
  
l. s. huang & c. f. huang  
  
finding indicates that, despite the existence of governmental regulations about pavement smoothness inspection and the use of the travelling beam devices, the overall pavement smoothness is still unsatisfactory in taiwan, posing a threat to the safety of both pedestrians and drivers. therefore, it is necessary to explore further this issue.   
  
the technology acceptance model (tam) can test the connections among users’ attitudes toward, willingness to use, and behaviors of using a certain technology (ong, et al, 2004). tam is mainly intended to explore how different factors affect one’s perceptions of the usefulness and ease of use of a technology. proposed by davis et al. (1989), the tam is mainly based on the theory of reasoned action developed by fishbein and ajzen (1975). the tam mainly discusses the connections between emotional variables and technology usage. it features such strengths as simple modeling, specific focus on information technology robust theoretic foundations, and sufficient empirical support. the modeling of the tam is shown in figure 1. according to chau (1996), since it was proposed, tam has been very popular and widely applied in information technology and management fields. therefore, there have been many applications and much empirical support of this model. succi & walter (1999) found the tam capable of explaining the acceptance level of a user toward a new information technology and forging connections between beliefs and attitudes to predict acceptance levels of a new technology. morris & dillon (1997) thought, empirically applied or not, the tam is a successful and easy-to-use system providing predictions that can help researchers and practitioners to save costs.   
  
  
  
figure 1. modeling of the tam   
  
using the tam as its theoretical foundation, this study attempts to explore the effectiveness of using profilograph devices by conducting a questionnaire survey to find out if the respondents’ previous experiences and training/support about using the devices affect their perceived usefulness and ease of use of the devices and also to find out if their perceived usefulness and ease of use of the devices affect their actual use of the devices. the purpose of this study is to help the related organizations and the device users in measuring and improving the pavement smoothness by encouraging the users’ willingness to use the devices more frequently. in addition, king and he (2006) conducted a meta-analysis on a total of 88 studies and found, even though one’s perceived usefulness of a technology has a significant influence on behavioral intention, perceived ease of use of the technology does   
  
2184   
  
  
  
  
  
eurasia j math sci and tech ed   
  
not have a direct and stable influence on behavioral intention. in other words, it is still necessary in this study to establish that there are positive correlations between the respondents’ perceived ease of use of the devices and their attitudes and willingness to use the devices.   
  
according to the previous research (ong, et al, 2004) (chau, 1996) etc. the tam used in this study is composed of four major dimensions: previous experience, training and support regarding the use of the devices, perceived usefulness, and perceived ease of use. each of the dimensions is explored to find out its connections between the attitudes and willingness of the users to the use of travelling beam devices. the modeling framework of this study is shown in figure 2.   
  
  
  
figure 2.research framework of this study   
  
material and methods   
  
the subjects of the questionnaire survey in this research are employees of t construction firms in taiwan. all the 36 questions in the questionnaire were designed based on