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Using dynamic analysis of site vibration to select the suitable vibration limit

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KEYWORDS

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Abstract This study was done to select the appropriate vibration standard to be the adopted vibration standard for a construction project that was located in adjacent to many buildings. These buildings may be affected by project activities induced vibrations.

Three common international vibration standards were revised and based on the dynamic analysis results, site conditions, the nature of the existing buildings and the expected construction activities, and the most appropriate vibration limit criteria were selected and tested then validated. The selection process was based on experimental study carried out using physical models and real vibration data recorded on the construction site. The validation process was based on monitoring the vibration effects on existing buildings.

Experimental program was carried out using three physical models with dynamic characteristics within the range of the common existing buildings. These models were subjected to free vibration modal testing to ensure their dynamic characteristics. Three numerical finite element models for the three physical ones were built and calibrated using the free vibration test results. The numerical models were subjected to time history dynamic analysis using the vibration waveforms that represent the most effective construction vibrations. These waveforms were recorded onsite during different activities of the pilot project which was implemented to test all the project activities.

The validation process was carried out by applying monitoring program on two of the project neighboring buildings. These buildings were selected to represent the most likely to be affected buildings by the construction activities. The monitoring program includes vibration and strain measurements for the building vibration responses.

The results of validation process showed that the effectiveness of the selected vibration standard in estimating the level of damage on buildings subjected to the construction induced vibration.

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Introduction

Vibrations induced by construction equipment operations and near site traffic may have impacts on the adjacent structures. The level of impact depends on the distance from vibration

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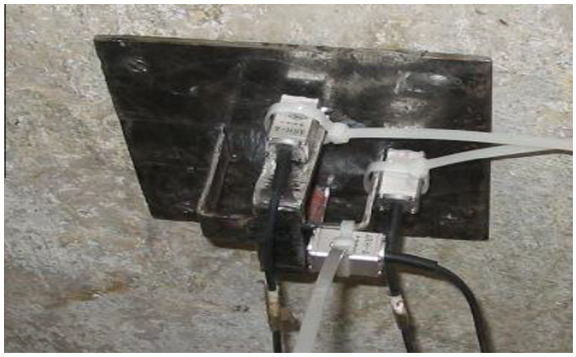

Fig. 1 Three accelerometers used to record the three vibration components.

Fig. 2 Boring machine during drilling process.

source, the vibration nature of the used equipment and the construction schedule activities. The vibrations with high levels may cause deformations, wall and/or slabs cracking, falling down of cladding and aggravation of existing cracking in structural members. Also vibration with long periods can lead to fatigue and over stress problems. The vibration quantities used to determine the vibration levels or magnitudes are acceleration, velocity and displacement.

Many previous studies were done to study the effect of vibration level on structure integrity or serviceability. Hunaidi et al. [1] describe the nature and causes of traffic-induced vibrations in buildings, and discuss possible remedial and preventive measures. Amick et al. [2] presented a study for performing site-specific assessment of the impact of construction vibrations on vibration-sensitive facilities. The study made an expansion of the existing methodologies such that frequency content is included. Khamis et al. [3] tested several forms of vibration criteria, as well as the results of an investigation on vibrations induced by construction traffic. Levels appeared well below the established Swiss criteria. Jones et al. [4] introduce an outlines for avoiding and addressing potential problems related to effect of vibrations on buildings by using the following steps:

(1) Identify potential problem areas surrounding the project site.
(2) Determine conditions that exist before construction begins.
(3) Inform the public about the project and potential vibration-related consequences.
(4) Schedule work to reduce adverse effects.
(5) Design construction activities to reduce vibration.
(6) Notify nearby residents and property owners that vibration-generating activity is imminent.
(7) Monitor and record vibration from the activity.
(8) Respond to and investigate complaints.

Hashad [5] studied the effect of traffic and construction induced vibration on two buildings and compares the results to two international vibrations. The results of this study concluded that the vibration records may be used to determine the stress levels in buildings subjected to vibrations due to traffic loadings or construction activities. Kotb et al. [6] provided an assessment of different international standards for evaluation of building vibrations. A comparative study for the most common international vibration standards was performed. The study has concluded that, there is a need to carry out experimental measurements to determine the additional stresses in structural elements due to vibrations.

There is a certain need to select criterion based on true experiments that measure the additional stresses in structural elements due to vibrations.

Hashad [7] studies the relationship between additional stresses on building induced by vibrations, vibration nature and building dynamic characteristics. The results of this study concluded that the building additional stress level induced by vibration depends on the nature of these vibrations and the building dynamic characteristics.

This study was done to introduce a method to select the most appropriate vibration standard from three available international standards DIN 4150, SN 640 312 and BS 7385 [8–10] to be the adopted vibration standard as required by the submitted protection plan for one of the construction projects, that was carried out for strengthening and stabilizing of two rain drainage tunnels in Saudi Arabia. The project path is adjacent to many buildings. The protection plan is aimed to ensure the integrity of these buildings to be not affected by vibrations resulting from the construction activates such as drilling or tunnel filling. This plan controls on the construction vibration by establishing a system for vibration monitoring and building inspections.

This research work deals with structure overstressing as global behavior. The vibration local effects on secondary structural members, nonstructural members or human comfort are not considered.

Site vibration records

Through the pilot project field experiments were done to collect the actual vibration signals that will be received by the adjacent structures during the project construction activities. The accelerometers were attached to a measuring point near the ground level, almost above the building foundation. The measuring point was chosen to represent the situation of the most critical building position. The structural system of the common buildings was reinforced concrete skeleton system and the building heights range from two to four stories. Three

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