A research study of the installation of an accelerograph network in Cusco, Perú

Un estudio de investigación sobre la instalación de una red de acelerógrafos en Cusco, Perú

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ABSTRACT

Peru is located in a seismically active location due to the interaction of the Nazca and South American plates, as well as surface faults that cause significant earthquakes across the continent. These seismic episodes generate seismic forces that affect structures, frequently resulting in substantial material and human losses in Peruvian sensitive buildings. Peru's most recent significant seismic events were in 2001 in Arequipa and 2007 in Pisco, with magnitudes of Mw 8.4 and 7.9, respectively. When these earthquakes happened, Peru lacked the instrumentation necessary to record them, and hence only a few sites documented them. As a result, the goal of building an accelerograph network at the National University of San Antonio Abad del Cusco's headquarters was proposed.

The development of an accelerometer network would allow for an improvement in the administration of seismic data. This included determining the technical elements of an accelerograph network, its installation, infrastructure, measurements, unit costs, budget, and plans. As a result of the investigation, a suggestion is made to implement KINEMETRICS, REFLEK 130 SMA and 130 SMHR accelerographs with a resolution of 24 bits on a server model PROLIANT DL380 G9. Additionally, it would include internal equipment such as battery installation, battery cable connection, and fastening sensor cable terminals; as well as exterior equipment such as GPS, ethernet, power, and Wi-Fi module installation.

Keywords: accelerographs network, earthquakes, Peru.

RESUMEN

Perú se encuentra en un lugar sísmicamente activo debido a la interacción de las placas de Nazca y Sudamericana, así como a las fallas superficiales que provocan importantes terremotos en todo el continente. Estos episodios sísmicos generan fuerzas sísmicas que afectan a las estructuras, resultando frecuentemente en importantes pérdidas materiales y humanas en los edificios sensibles peruanos. Los últimos eventos sísmicos significativos en Perú fueron en 2001 en Arequipa y en 2007 en Pisco, con magnitudes de Mw 8,4 y 7,9, respectivamente. Cuando se produjeron estos terremotos, Perú carecía de la instrumentación necesaria para registrarlos, por lo que sólo unos pocos lugares los documentaron. Por ello, se propuso el objetivo de construir una red de acelerógrafos en la sede de la Universidad Nacional de San Antonio Abad del Cusco. El desarrollo de una red de acelerógrafos permitiría mejorar la administración de los datos sísmicos. Para ello se determinaron los elementos técnicos de una red de acelerógrafos, su instalación, infraestructura, mediciones, costos unitarios, presupuesto y planes. Como resultado de la investigación, se sugiere implementar los acelerógrafos KINEMETRICS, REFLEK 130 SMA y 130 SMHR con una resolución de 24 bits en un servidor modelo PROLIANT DL380 G9. Además, se incluiría el equipamiento interno como la instalación de la batería, la conexión del cable de la batería y la fijación de los terminales del cable sensor; así como el equipamiento exterior como la instalación del GPS, ethernet, alimentación y módulo Wi-Fi.

Palabras clave: red de acelerógrafos, terremotos, Perú.

1 INTRODUCCIÓN

Peru is located in a zone of high seismic hazard, where the last major seismic events of 8.4 Mw=8.4 and Mw=7.9 occurred in 2001, in Arequipa, and in 2007, in Pisco, respectively. At that time, Peru did not have sufficient instrumentation to measure seismic events, so few stations were able to record such events (Alva et al., 2020). This led the National University of San Antonio Abad del Cusco in 2017, to analyze the possibility of the implementation of the Installation of an Accelerographic Network in the University's Headquarters, determine the characteristics of accelerographs in the Implementation and improve the scopes of the Standard E-030 of the National Building Regulation (RNE).

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Theoretical framework

Accelerographs are instruments for recording seismic movements, they produce records called accelerograms and their mission is to reproduce in a very realistic way the acceleration of the earth where they are located. The main objective of the Accelerographic Network is to generate greater knowledge of the dynamic behavior of soils for the elaboration of seismic wave attenuation laws through the implementation of accelerographic stations. The instruments of the accelerographic network are being installed in Peruvian universities, which allow generating information of accelerograms of open distribution and use, which contributes with engineers, university professors and students to develop research oriented to the update of the Peruvian national regulations (Seismic Resistant Design norm (E.030) and Soil and Foundations norm (E.050)). Its use is also important for the definition of criteria for micro and macro zoning studies, seismic risk studies, evaluation of the response of civil works, damage in buildings and infrastructure works before severe seismic events, generation of information necessary for the evaluation of the seismic threat and the generation of information for the institutions linked to the prevention, mitigation and alert before seismic events.

Currently in Peru there are the following accelerographic networks: CISMID - FIC - UNI, SENCICO accelerographic network, national seismological network in charge of the Geophysical Institute of Peru (IGP).

2 METHODOLOGY

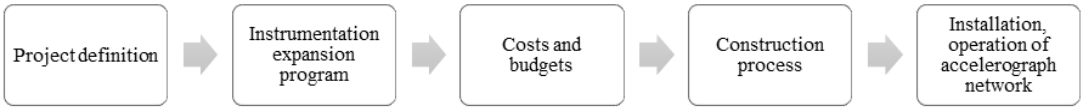
Technical details, it is proposed that the accelerographs, are in the models KINEMETRICS, REFLEK 130 SMA and 130 SMHR of 24 bits of resolution, have three (3) channels, capacity to record 200 points per second, 16GB of memory and a sensitivity that goes from 0. 0001g to 4g. and the SERVER, model PROLIANT DL380 G9, installed the software for the management of the Tremble Reftek seismic accelerometric recorders, model 130-SMA: RT VIEW, RT_DISPLAY and RTCC.

Construction process of the accelerograph network

1. Determine the locations for the construction and installation of accelerograph networks. Likewise, accelerograph and server technologies are reviewed.
2. Planning of activities to be carried out, for which the activities, their duration and geographic location must be defined.

3. An offer study is carried out by means of quotations to know the costs of accelerographs, servers and supplies. Then the budget is established.
4. It is the stage of execution of the civil works, where the foundations, columns, solid slab, brick laying, pedestal, tiling, painting of walls, sanitary installations and electrical installations are carried out.
5. The installation and operation of the accelerograph network is completed through the interconnection of the server with the accelerographs.

Illustration 01: Accelerographic Network Installation Implementation Flow Diagram



3 RESULTS

Illustration 2 shows the budget structure, for this purpose it was considered that the work would be carried out under contract (indirect). Likewise, the execution is scheduled for three and a half months, taking into account general, supervision, follow-up and technical file expenses.

Illustration 02: Budget structure of the accelerographic network

Description	Amount
Direct Cost	USD 139,294.02
General expenses	USD 35,857.20
Profit	USD 13,929.40
Subtotal	USD 189,080.62
General Sales Tax (18%)	USD 34,034.51
Cost of contract work	USD 223,115.14
Project management and follow-up expenses	USD 32,731.96
Construction supervision	USD 20,264.18
Technical file expenses	USD 8,942.97
Total, base budget	USD 285,054.24

4 DISCUSSION

The Peruvian National Building Regulations (RNE), in norm E.030 establishes that projects from 10,000.00 m2 or more, must be instrumented with a triaxial accelerographic recorder (*Article 25.- Accelerographic Recorders: In all seismic zones, building projects with an area equal to or greater than 10,000 m2, must be instrumented with a triaxial accelerographic recorder. Triaxial accelerographic recorders must be*

provided by the owner, with technical specifications approved by the Geophysical Institute of Peru). However, the RNE makes no mention of existing infrastructure, which leads to a lack of awareness of seismic databases, risk management, among others. Likewise, the RNE mentions a type of triaxial accelerographic recorder. This is a relevant proposal, but it is necessary to implement new accelerograph network technologies in existing buildings as well as in projects. It is also necessary to motivate and promote a risk culture in the different educational stages of students.

5 CONCLUSIONS

The total execution budget of USD 285,054.24 (two hundred and eighty-five thousand and fifty-four with 24/100 American dollars), by the modality of contract, for the implementation of an accelerographic network in the headquarters of the National University of San Antonio Abad del Cusco. The characteristics of the accelerographs are Model 130SMA, with three channels, 24 bits resolution, Ethernet - Serial communication, with accessories with GPS and server model PROLIANT DL380 G9. These will allow the implementation of an Accelerographic Network Installation.

The costs for the implementation amount to: direct cost US$ 139,294.02; general expenses US$ 35,857.20, profit US$ 13,929.40, General Sales Tax US$ 34,034.51, project management and follow-up expenses US$ 32,731.96, work supervision US$ 20,264.18 and technical file expenses US$ 8,942.97. This makes a total budget of US$285,054.24. This total amount is an affordable amount that can be invested in the execution cycle of Invierte.pe. The implementation of the Accelerographic Network will make it possible to comply with Article 28 of the E.030 Standard of the National Building Regulations (RNE). Because the information would be in the public domain and would be available to users upon request. For the implementation of the Accelerographic Network, it is necessary to define the project, program the expansion of instrumentation, costs and budgets, construction processes, and the installation and operation of the network.

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