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Halifax Regional Council
February 13, 2007

TO: Mayor Kelly and Members of Halifax Regional Council

SUBMITTED BY: Dan English, Chief Administrative Officer

Mike Labrecque, Director, Transportation & Public Works

DATE: January 25, 2007

SUBJECT: **Award - Metro Centre Structural Health Monitoring System**

ORIGIN

The Halifax Metro Centre was constructed in the late 1970's, to provide an indoor venue large enough to hold major hockey events in Halifax. Since its construction, regulations controlling the limits of roof snow loadings have increased. In conjunction with the ever increasing use of suspended equipment for lights and sound by the many special events seeking to perform at this venue, it is necessary that the capacity of the Halifax Metro Centre structure needs be monitored and possibly upgraded.

RECOMMENDATION

It is recommended that Council award Metro Centre Structural Health Monitoring System to SMARTEC SA for a total Tender Price of $137,560.00 (net HST included), with funding from Capital Account CB300555, as outlined in the Budget Implications section of this report.

BACKGROUND

Due to its strategic location, the Metro Centre has successfully played host to a wide range of indoor events that do not require an ice surface. The events range from the Annual International Tattoo, to various musical events such as Celine Dion Show, Celtic Tiger and the Junos 2006 Awards, to the recent Toyota Matrix Launch.

The successful operation of the facility has not been without its share of problems resulting from the structural loading requirements of each event. The problems can generally be attributed to the following factors:

1. Entertainment Loads

The majority of the events involve the extensive use of light, sound and video equipment and many other forms of display systems weighing several thousand kilograms. In order to maintain an unobstructed view of the stage, these loads, commonly referred to as *the entertainment loads*, are suspended from various members of the roof truss members. The magnitude and the location of these loads vary from one show to another according to its artistic and functional design. To correctly position a temporary load at a specific location, it may have to be suspended by means of two or more cables attached to members of different trusses. This complex manner of load suspension creates a 3-Dimensional load effect making it extremely difficult to accurately analyze the combined effect of multiple loads without the use of sophisticated structural analysis software. With each passing year, the number and the magnitude of the total entertainment loading have been steadily on the rise.

2. Snow Loads

In Canada, the snow load is one of the most important factors to be considered in the design and capacity of a roof structure. The magnitude of the design snow load is determined in accordance with the procedure laid out in The National Building Code of Canada (NBCC). The NBCC mandates that during the winter months (October to April), the snow load effects must be taken into account while determining the capacity of a roof structure to support any additional load. After allowing for the snow load, the capacity of the Halifax Metro Centre roof structure to support the entertainment loads is significantly reduced. Analyses carried out in the past indicate that some of the roof trusses have no reserve capacity left to support suspended loads of any magnitude during winter.

3. Increased Design Snow Loads - Revisions to National Building Code of Canada

The Metro Centre was constructed in the late 1970's, according to the then current National Building Code of Canada (NBCC). Subsequently, there have been five revisions to the building code (1980, 1985, 1990, 1995 and 2005). The 1995 and 2005, revisions led to higher values of design snow loads. The increase in the basic snow load factor for buildings with large roof areas

and the inclusion of the facility importance factor in the NBCC 2005 have resulted in the design snow load values that are significantly higher than those used in the original design.
The analysis of the roof structure performed after the 1995 code revision indicated that in winter, 50% of the roof trusses did not have any reserve capacity to support the entertainment loads while the remaining 50% had only a limited capacity. The analysis performed after the 2005 code revision showed that parts of the structure would be over stressed under the revised snow loads, and there would be no capacity to support the entertainment loads during winter. In today's rapidly expanding entertainment industry, the ability of a major venue to host significant events could be compromised by the lack of capacity to accommodate such loads.

DISCUSSION

In March 2006, MacDonnell Group was asked to study the entertainment and snow load related issues and recommend a long-term solution.

The study was carried out by the firm under the three following categories dealing with various aspects of the issue:

Step-1 Permissible Snow Depths
Step-2 Roof Structure Strengthening Options
Step-3 Structural Health Monitoring System for Metro Centre

In light of the information gathered in the study, there were two options available to manage the loads on the Halifax Metro Centre Roof.

Option-1: Strengthening Only

This option would see the structure strengthened immediately taking into account the NBCC (2005) snow loads and the entertainment loads. At this point, the anticipated structural upgrades would have to be determined through the use of a sophisticated 3-dimensional structural modelling program. As sophisticated as these programs currently are they are not as effective as studying the actual impact of real loads on the structure. This is because over time some members and joints may have weakened, but also because the actual structure may act differently than the best of models can predict. Relying solely on the model might result in either under design or costly over design of structural members.

Option-2: Monitoring and Strengthening

This option would see the structure monitored and strengthened based on the acquired data from a Structural Health Monitoring (SHM) system. In recent years, Structural Health Monitoring (SHM) has emerged as an innovative way to manage the loads on structures. The rationale for adopting this strategy is as follows:

As far as the snow and the wind loads are concerned, each structure is unique due to its configuration and the environment in which it exists. The site-specific data can be obtained by

installing a Structural Health Monitoring (SHM) system to monitor the performance of the roof structure under actual snow and entertainment loads. It is expected that some form of strengthening may eventually be needed, and by using the acquired data a better and more cost-effective strengthening strategy can be formulated. Furthermore, the monitoring system can also be utilized to observe the effects of entertainment loads in real time, while increasing the safety of the occupants and improving management capabilities.

Monitoring System

A monitoring system comprises an array of strategically placed sensors on the structure connected to a central data acquisition system that is linked to a computer with the necessary software. The data acquired from the sensors is processed and displayed on screen and stored. The system can be programmed to generate warnings or alarms to alert the user in the case sensor signals exceed certain predefined thresholds.

Three different types of sensors were considered in the study; foil strain gauges, vibrating-wire stain gauges and fibre optic sensors. The signals from the first two sensor types, which work on electrical current, can potentially be influenced by the electromagnetic interference from various electrical devices operating at or near the truss level where these sensors will be attached. Considering the large volume of electromagnetic interference potentially generated by the proposed suspended equipment, these two systems were not considered as viable options. Further, both of these sensors are prone to degradation, or wandering off calibration, and would not provide long-term structural feedback after having been used for the initial analysis. Fiber optic sensors operate on a laser light source and are therefore inherently immune to such interferences and are the sensor type that is recommended for installation in this option.

Recommended Option

Option-2 is recommended because this strategy would be more reliable than Option-1 and could potentially result in reduced strengthening costs. To implement the system, a portion of it, mainly fiber optic sensors and integrated system, has been identified from a single supplier SMARTEC SA of Switzerland. It is recommended that the procurement proceed based on the following:

Sensor Manufacturer Selection

There are several components to the proposed monitoring system; the sensors, the central data acquisition system, and the computer based interpretive software. There are two types of fiber-optic sensors; bondable, and detachable. The bondable sensors, once bonded, can not be removed or reused elsewhere. The detachable sensors, as the name suggests, can be detached, relocated, and reused. To facilitate the rigging of entertainment loads, it is important that the sensors can be detached temporarily and reinstalled easily. SMARTEC is the only known manufacturer of detachable fiber-optic sensors. SMARTEC is the most internationally renowned manufacturer of fiber-optic sensor based structural measurement and monitoring systems.

A structural monitoring system requires integration of many different components and software to perform satisfactorily. The operation and maintenance of an assembly of various components acquired from several different manufacturers can potentially lead to compatibility issues that may prove difficult and costly to resolve. In the case of a malfunction, either of a component or software, it is often difficult to establish the liability for repair or replacement in a system having components procured from various different manufacturers. SMARTEC manufactures fiber-optic sensors and several other components of the monitoring system. The components that are not manufactured by SMARTEC are provided by SMARTEC as original equipment manufacturer (OEM) and carry SMARTEC warranty.

The sole sourcing of the monitoring system from SMARTEC SA is recommended due to the following reasons:

- Only manufacturer of detachable fiber optic sensor
- Integration of components
- International reputation and reliability
- On site support during installation commissioning

Recommended System

The recommended system consists of 36 detachable fibre optic sensors connected to the main data acquisition system through two central measurement points (CMPs) located on the trusses. The data acquisition system, housed in a room at the skybox level, will be linked to a personal computer with the necessary software to analyse, display and store the acquired data. This information can be remotely viewed through the existing wired communication system available on site. The recommended system will also have provision for 36 additional sensors that can be installed without any significant interruption to the day-to-day operation of the Metro Centre, in case the monitoring capabilities need to be expanded. An optional deflection monitoring device can be installed to monitor the mid-span deflection of the four main trusses in real time. This will enable real-time monitoring of entertainment load suspension.

BUDGET IMPLICATIONS

Based on the tendered price of $137,560 (net HST included), funding is available in the Capital Budget from Capital Account No. CB300555 - Major Facilities Upgrades, Reservation No. 1037.9. The budget availability has been confirmed by Financial Services.

Budget Summary: Capital Account No. CB300555 - Major Facilities Upgrades
Reservation No. 1037.9

Cumulative Unspent Budget	$185,022.96
Less: SMARTEC Structural Health Monitoring System	$137,560.00
Balance	$ 47,462.96

* This cost to HRM includes net HST. The quotation from SMARTEC is $140,437 Swiss Francs. Fluctuations in the exchange rate may cause the equivalent number in Canadian Dollars to vary slightly.

The balance of funds will be used for installation of the sensors and additional capital improvements at the Halifax Metro Centre.

FINANCIAL MANAGEMENT POLICIES / BUSINESS PLAN

This report complies with the Municipality's Multi-Year Financial Strategy, the approved Operating, Capital and Reserve budgets, policies and procedures regarding withdrawals from the utilization of Capital and Operating reserves, as well as any relevant legislation.

ALTERNATIVES

There are no recommended alternatives to sole sourcing this system. Staff believe that this is the only system currently available that will provide the on going level of monitoring required at this site.

ATTACHMENTS

No attachments.

A copy of this report can be obtained online at http://www.halifax.ca/council/agendasc/cagenda.html then choose the appropriate meeting date, or by contacting the Office of the Municipal Clerk at 490-4210, or Fax 490-4208.

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