Adaptable Three Dimensional System for Building Inspection Management

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Sustaining the safety and operability of civil infrastructure assets, including buildings, is a complex undertaking that requires a perpetual cycle involving inspection, and further decisions for renewal fund allocation. However, inspection, which is the basis for all subsequent decisions, is a complex task to manage, particularly when a large number of assets are involved. The current lack of a structured process with visual referencing as well as the high subjectivity and inflexibility to changing inspection requirements make current inspections very costly and time consuming.

This research improves the building inspection process by introducing a 3D system for inspection management that has four unique features: (1) a structured assessment approach that considers multiple organizations, buildings and inspectors, using a GIS interface; (2) a 3D visual referencing method for marking problem areas during inspections to facilitate all on-site inspections, thus reducing time and cost; (3) a visual guidance module to reduce inspection subjectivity; and (4) a flexible module for designing different assessment types. The proposed inspection management system creates 3D building plans from 2D Computer-Aided Drawing (CAD) to provide location referencing that enhances inspection effectiveness. The visual guidance system allows inspectors with various experience levels to perform consistent inspections and requires less training, thus reducing costs. Flexible inspection generation also allows a variety of inspection types, such as condition and level of service, to be readily incorporated.

A computerized prototype system has been developed using the Windows Presentation Foundation's XAML markup language with underlying C# programming on a tablet computer for experimentation. The thesis provides a detailed description of system development and reports the benefits of the system on a sample inspection. Accordingly, the system has proven most useful for large organizations that own a large number of building assets that require frequent inspections.

Acknowledgements

First and foremost, I thank God for His countless blessings that enabled me to accomplish this effort.

I wish to express my utmost respect and appreciation to the guidance, patience and knowledge that was continuously and unconditionally bestowed by my supervisor, dr. Tarek Hegazy, who has given me much of his valuable time throughout my Master's program and made this effort possible.

I extend my gratitude to the generous funding from NSERC that enabled the successful completion of this research.

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Finally, I extend my humble gratitude to my parents, brothers and sisters, wife and son for their warming presence and support, without which I would not have been able to complete this work.

Dedication

This work is dedicated to my family; parents, siblings, wife and son for their unconditional support

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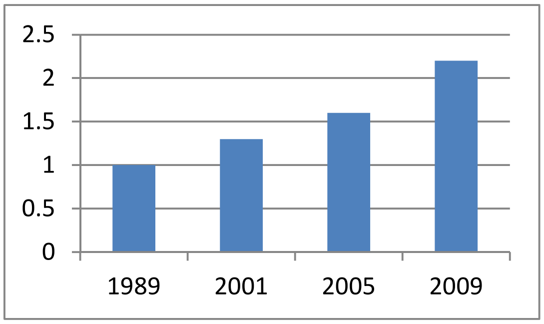
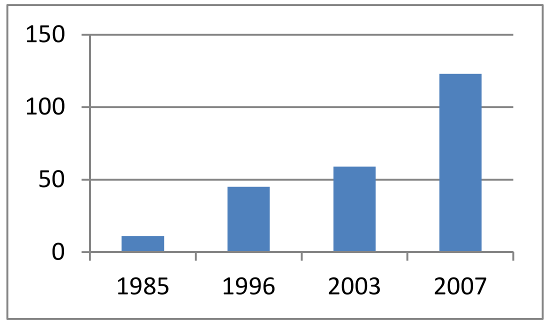
Chapter 1
Introduction

1.1 General

Economic prosperity is facilitated by a healthy civil infrastructure, because infrastructure provides the basic facilities and services required to sustain society. Roads, bridges, power, communication and water/sewer networks as well as buildings and other infrastructure assets are normally owned and operated by the government and other large organizations. Despite ongoing research since the 1980s, the state of North American infrastructure is still deteriorating and the majority of the infrastructure is in critical condition. Aging, weather, increased population, and the lack of maintenance and funding contribute to the increased difficulty in sustaining healthy infrastructure (McQuaid 2007). In fact, infrastructure in Canada and the United States has been deteriorating for decades and causing a backlog in maintenance and repair funding (Singh and Hegazy 2005). The American Society of Civil Engineers published a report in 2009 (Marrano and Grussing 2010) stating that USD 2.2 trillion are required to bring the state of infrastructure assets to an acceptable condition compared to a previous estimate of USD 1.6 trillion in 2005. The Canadian maintenance backlog is also high, and was estimated at CAD 123.6 billion by the FCM-McGill survey (2007). Deficit increases in Canada and the United states are illustrated in Figure 1.1.



USA Infrastructure Deficit USD Trillion
(Marrano and Grussing 2010)



Canada Infrastructure Deficit CAD Billion
(FCM-McGill 2007)

Figure 1.1 Infrastructure Deficit in Canada and the United States

The deteriorating infrastructure results in structural failures, large economic costs, loss of life and loss of productivity. For example, an 8-lane highway in Minneapolis collapsed in August of 2007, causing the death of 13 people and injury to 145 more. In July of the same year, an 83 year old steam pipe exploded in Manhattan causing one fatality (Reid 2011). The Texas Transportation Institute's 2011 Urban Mobility Report (Schrank et al. 2011) reported that 1.9 billion gallons of fuel were wasted due to road congestion, at the cost of USD 101 billion and resulting in 4.8 billion hours wasted by Americans in 2010. Furthermore, incurred costs due to congestion are rapidly increasing, as illustrated in Figure 1.2.

Non-residential buildings (e.g. schools, facilities) represent one of the largest infrastructure sectors. The best estimate states that USD 322 billion is needed to bring US schools alone into a state of good repair (ASCE 2009).

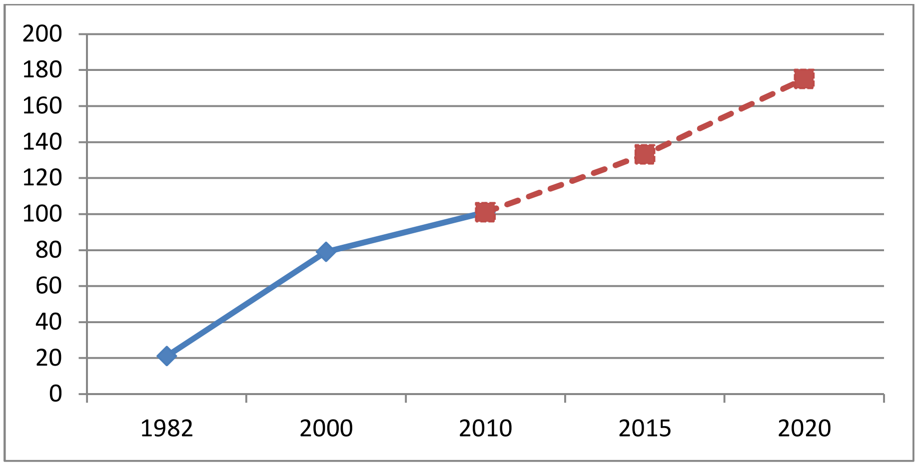


Figure 1.2 American Costs of Congestion in USD Billion (Schrank et al. 2011)

It can be argued that the increasing infrastructure backlog is due in part to less structured procedures for inspection and fund allocation to various assets. An example of an infrastructure failure due to inadequate inspection is the Ka Loko Dam breach in Hawaii. The 2007 Report of the Independent Civil Investigation (Godby 2007) suggested that the 1972 classification of the Ka Loko Dam in Hawaii by the Army Corps of Engineers as a low-hazard dam resulted in neglect of its inspection over the years. This neglect continued with the dam classification unchanged, causing failure of the maintenance process. On March 14, 2006, the dam was breached due to heavy rain and poorly-maintained structure and equipment, releasing around 1.6 million tons of water, killing seven people and destroying huge areas of land and ocean reef, buildings and equipment.

1.2 Research Motivation

This research aims at developing a structured inspection management system that focuses on building inspection management and uses visual support tools, including pictorial guidance, a geographic information system (GIS), 3D modeling and adaptable inspection design. The motivation for designing the inspection management system is summarized in the following subsections.

1.2.1 Unstructured Inspection Management

For large organizations that own a large inventory of buildings, inspection management is a difficult task. A recent example of a large inspection task requiring efficient management is a bid issued in 2010 by the Ontario Ministry of Education seeking a company to inspect more than 4800 schools that belong to 72 school boards in a 5-year period (MERX 2011). Any development company that is interested in this project has to present an efficient management system that integrates many functions: inspection planning for multiple buildings in multiple organizations (school boards), managing various inspection types, building requests, school board reports, ministry reports, component by component reports, inspection devices, etc. While many inspection systems exist in the industry market, they are mostly suitable for inspections intended for a single facility. There is a need, therefore, for a structured inspection management system that includes the above components in a visual, easy to use system. Such a system will be suitable for use by municipalities or large organizations to use for infrastructure inspection management, that of hundreds of assets belonging to different organizations.

1.2.2 Lack of Visual Referencing During Inspection

Visual referencing is important for inspection accuracy and data communication between assessors, managers and decision-makers. Current inspection systems are text-based and may incorporate limited visual references, such as pictures taken using digital cameras. Visual referencing is mostly manual, labor-intensive and difficult to manage (Hegazy et al. 2008). There is a need for a portable tablet that combines the assessment process with visual referencing to the location of problems on the CAD plans, and automatically references any pictures, short videos and audio observations.

1.2.3 High Subjectivity in the Inspection Process

While audio and visual references to assets reduce subjectivity, assessments will still differ from one inspector to another, resulting in possible inconsistencies. Managers take decisions based on inspection assessment information (Hegazy et al. 2008). Reducing subjectivity results in more accurate assessment data, which in turn, provides a stronger basis for maintenance management decisions.

1.2.4 Lack of Adaptability to New Inspection Requirements

Government regulations are altered from time to time, such as in response to changes applied to handicapped accessibility regulations in different regions. An asset inspection management system has to allow for flexible design of the assessment surveys to incorporate such changes. Additionally, an asset inspection can contain several assessment elements that contribute to its overall rating, such as physical condition, level of service, risk and sustainability. Each assessment can have a different structure, apply to specific components, incorporate specific questions and have different inspection needs. Different rating systems exist, and classify the overall rating of assets (e.g. excellent-critical). Organizations have different structures and organizational divisions, including administrative personnel levels and inspector types. The dynamic nature of assessments and organizations require an adaptable system that can handle different cases and be tailored to inspection managers' needs (Hegazy 2010). This system has to allow flexible design of new assessments and system administrators should be able to set specific questions that apply to a custom inspection.

1.3 Research Objectives and Scope

The primary objective of this research is to develop a flexible framework to support visual inspection of buildings. The proposed framework will address the problems associated with the traditional process of assessing the condition of building assets. The detailed objectives of the present research are to:

1. Clarify *the* challenges of asset management by investigating the current state and requirements of contemporary asset management as viewed by large infrastructure asset inspection management organizations.

2. Restructure the condition inspection process into a location-based process that uses 3D visual tools to enable better identification of problem areas during *inspections*.
3. Develop a framework for inspection management that accounts for multiple *organizations*, buildings, components, inspections and assessors.
4. Incorporate a flexible inspection survey design tool to enable creation of custom surveys that suit the varying requests of inspection types; and
5. Develop and test a prototype inspection management system.

The system is intended for large-scale applications, where a static system is impractical and a large amount of information is handled. The framework is designed for buildings, but it may be extended to manage inspections of other types of systems including road, water and sewer networks. Upon implementation, the adaptable system will greatly improve maintenance decisions by providing consistent, accurate and accessible information about assets and reduce the costs and efforts of asset inspection management.

1.4 Research Methodology

The methodology followed to achieve the research objectives is represented in Figure 1.3:

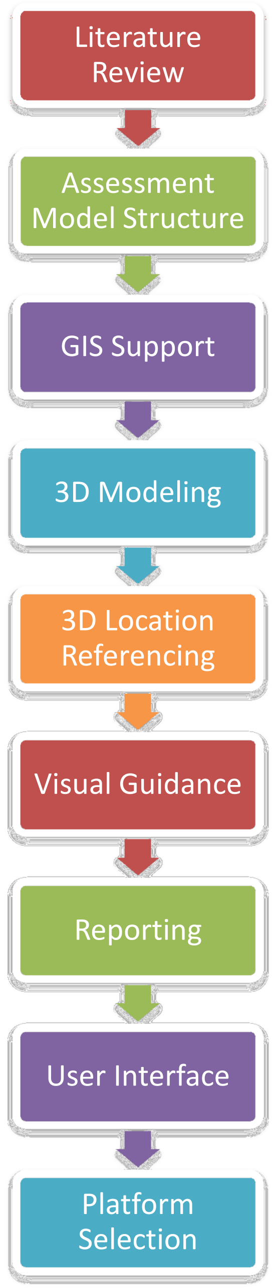


Figure 1.3 Research Methodology

1. Conduct a literature review: An investigation into existing inspection management *systems* to determine available tools and methods for data visualization is to be performed. The review will further reveal tools and

methods applied in current inspections as well as proposed improvements to inspection management systems.

2. *Develop* an assessment structure: An assessment structure is to be based on an inclusive model that satisfies most contemporary inspection management system requirements. The structure allows multiple levels of details as well as index values that are associated with the importance of assessments. The structure also standardizes hierarchical organization and component classifications.

3. GIS *Support*: An integrated GIS system will visually represent the locations of facilities, assignments and reports. GIS data availability will present data to users based on their region and access levels.

4. 3-dimensional modeling: Building models will be generated from building *drawings*. Building models will be presented as easy to navigate 3D models that are accessible by facility, building, floor or floor element, such as individual rooms. The model will also allow inspectors to mark defects directly on the 3D building model and display color coded defect information on the 3D model.

5. Visual Referencing: In addition to performing assessments, the system will allow *inspectors* to take digital photographs and videos and to record audio memos. The recorded media will automatically be associated with the assessed component and available for reference.

6. Visual guidance: While assessing components, inspectors will be presented with photos of similar components in various conditions and bearing different possible defects as well as descriptions of those conditions and defects. This will allow inspectors to make consistent observations and reduce inspection subjectivity.

7. Reporting: Reporting will be developed to enable visual access to inspection information.

8. User *interface*: The program's overall structure will be designed to provide an intuitive user interface and navigation model.

9. Platform *selection*: Suitable inspection system components are to be selected that include an inspection device, operating system and programming language.

1.5 Thesis Organization

Chapter 2 presents a literature review of recent asset inspection management tools and programs, where data representation and visualization is studied. Typical inspection management system structures and needs are also examined.

Chapter 3 further examines requirements of asset inspection management system by examining the requirements of large organizations for infrastructure management.

Chapter 4 discusses the infrastructure management system implementation based on the findings in Chapter 3. A sample interface that uses the discussed tools and requirements including GIS, CAD, 3D modeling, visual guidance and audio and visual tools is presented. An example inspection is also carried out at the end of the chapter to explore the effectiveness of the system.

Chapter 5 contains concluding remarks and acknowledges research contributions as well as future research.

Chapter 2
Literature Review

2.1 Introduction

While the most important factor to ensure a structure's quality integrity through its lifetime is the initial construction quality, the second most important factor is adequate inspection and maintenance, which is often neglected or underdone (Mirza and Haider 2003). This chapter presents a review of the state of infrastructure followed by an outline of the challenges in implementing an inspection management system. Finally, a review of the existing solutions is presented, followed by the conclusions on recommended implementation specifications of the infrastructure management system.

2.2 The Crumbling Infrastructure

Infrastructure assets span various important systems including water, wastewater, communication and electric networks, transportation system and public institutions such as educational and community facilities. The infrastructure deterioration problem has been an issue since the late 1970s. *America in Ruins: The Decaying Infrastructure* by Choate and Walter is an especially famous document that shed light on the existing state of infrastructure and its effects on property and quality of life (Ahluwalia 2005). It increased public awareness of structural failures and incidents involving infrastructure assets, which led to a better perception of the current infrastructure crisis.

Public condemnation has grown even further after a series of failures in 2007 including the Minneapolis bridge collapse and recurring airline problems, as outlined in the Texas Institute’s 2007 Urban Mobility Report. The Can’t-Do Nation: Is America Losing Its Knack for Getting Big Things Done? (McQuaid 2007), a newspaper article written by a Pulitzer Prize-winning journalist, mentions a 2005 Federal Highway Agency report following the Minneapolis bridge collapse that more than 75,000 U.S. bridges are structurally deficient. The article further highlights that the main reason for the Katrina Hurricane flooding disaster in 2005 was the failure of the flood-control system in New Orleans. Such flaws were overlooked for decades due to a poor infrastructure management system that allowed the failures to cost many lives and a huge economic bill.

2.3 The Effects of Deteriorating Infrastructure

As a result of continuous failure to perform maintenance, repair and rehabilitation operations, the overall costs of performing repairs increase non-linearly, causing a lower level of service and further maintenance backlog (Hudson et al. 1997). Figure 2.1 illustrates a typical S-curve for asset condition deterioration. For repair-type maintenance operations, it can be clearly seen that earlier maintenance yields better results for investments, whereas negligence results in expensive repairs that may be inefficient and may even require asset replacement. The result is compounded backlog as fewer funds are available for repairing assets in a timely manner and more costly emergency repairs are made. For instance, the estimate for repairing the U.S. Infrastructure over 15 years was estimated by a Joint Committee of the U.S. Congress at $1 Trillion in 1989 (Mirza and Haider 2003) and continued to rise until the most recent estimate of $2.2 Trillion in 2009 as illustrated previously in Figure 1.1.

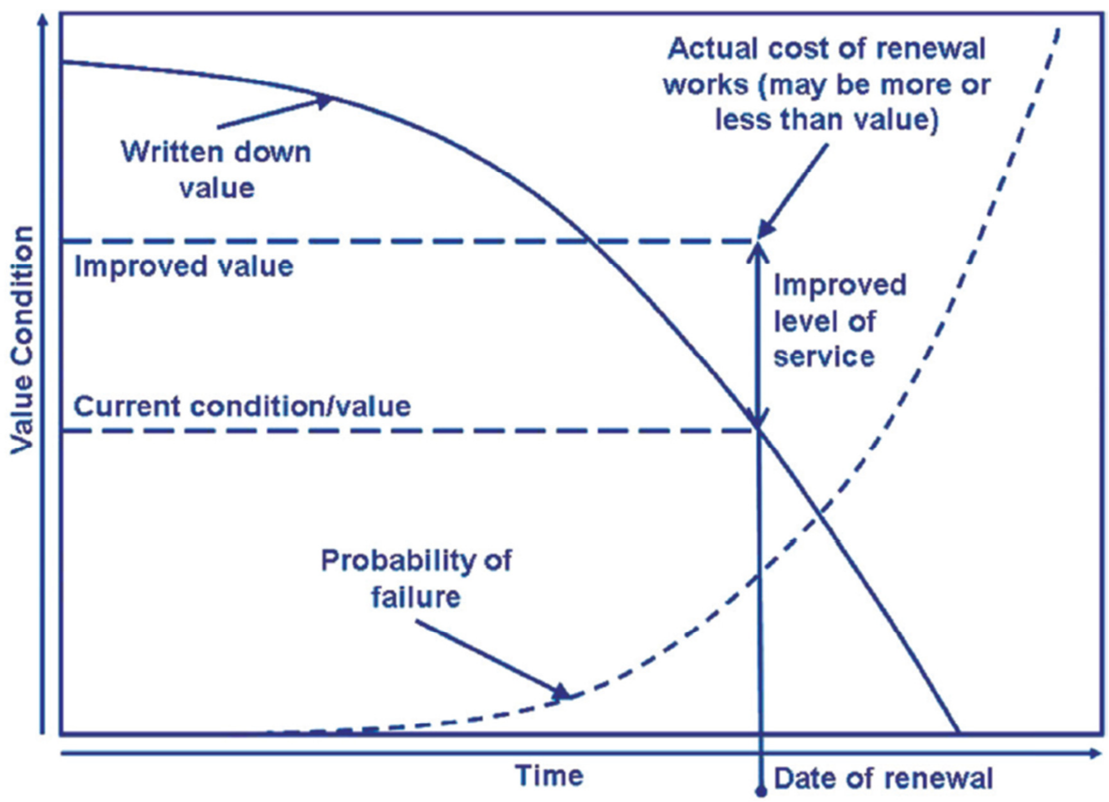


Figure 2.1 Effects of Maintenance, Repair and Rehabilitation on Condition (Hooper et al. 2009)

Failure to maintain infrastructure assets negatively affects prosperity and growth because it is the foundation of economic growth (Ahluwalia 2005). Different infrastructure asset failures also pose risks associated with health, safety and financial loss. An example of such an adverse effect on economic prosperity was the US Department of Transportation statement in the 1980s that by the mid-1990s, the deteriorating infrastructure would cost the American society 6% of its dispensable income, 2% of its employment growth and 3% of its manufacturing productivity (Mirza and Haider 2003).

2.4 Asset Management System

A number of systems have been developed to respond to the infrastructure asset inspection and maintenance management challenge. An asset management system as defined by Hudson et al. (1997) is a set of operations made of methods, procedures, data, software, policies, decisions etc. that enable activities involved in asset management whose main functions, as illustrated in Figure 2.2, include:

1. Condition assessment
2. Future deterioration modeling
3. Maintenance and repair strategies selection
4. Follow up condition improvements
5. Prioritization and budget considerations.

The most important step in asset maintenance is the condition assessment that outlines the ability of the asset in question to perform its intended purpose because everything that follows depends on an accurate assessment (Singh and Hegazy 2005).

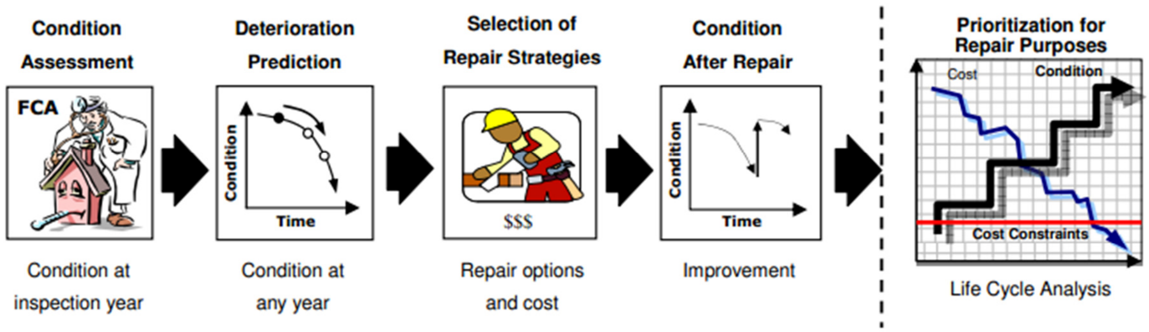


Figure 2.2 Main Functions of an Asset Management System (Ahluwalia 2008)

The US Army Corps of Engineers (USACE) Engineer Regulation ER 1110-2-100 (Engineers 1995) states that structure inspections are performed to provide reports for reference, record and as a basis for remedial work "…based on a detailed, systematic technical inspection and evaluation of each structure and its individual components regarding its safety, stability and operational adequacy".

Numerous approaches exist for carrying out inspections and maintenance operations. The Job Jar approach for asset maintenance management is one of the most common approaches. As illustrated in Figure 2.3, it relies on inspections to identify deficiencies, from which work packages are developed (Uzarski et al. 2009). Budgets and prioritizations are then set up based on the resulting work packages. While the approach is tried and proven for repairing deficiencies, it has several shortfalls that need to be addressed to improve its efficiency including:

1. A *deficiency*-based approach forgoes optimization opportunities because it only focuses on deficient assets;
2. Its frequency is often based on regulation, which leads to under inspection and missed repair, rehabilitation and renewal opportunities;
3. Due to *funding* constraints and inspection frequency, maintenance jobs can become obsolete by the time the maintenance operation is ready to be performed, and a new assessment becomes necessary.

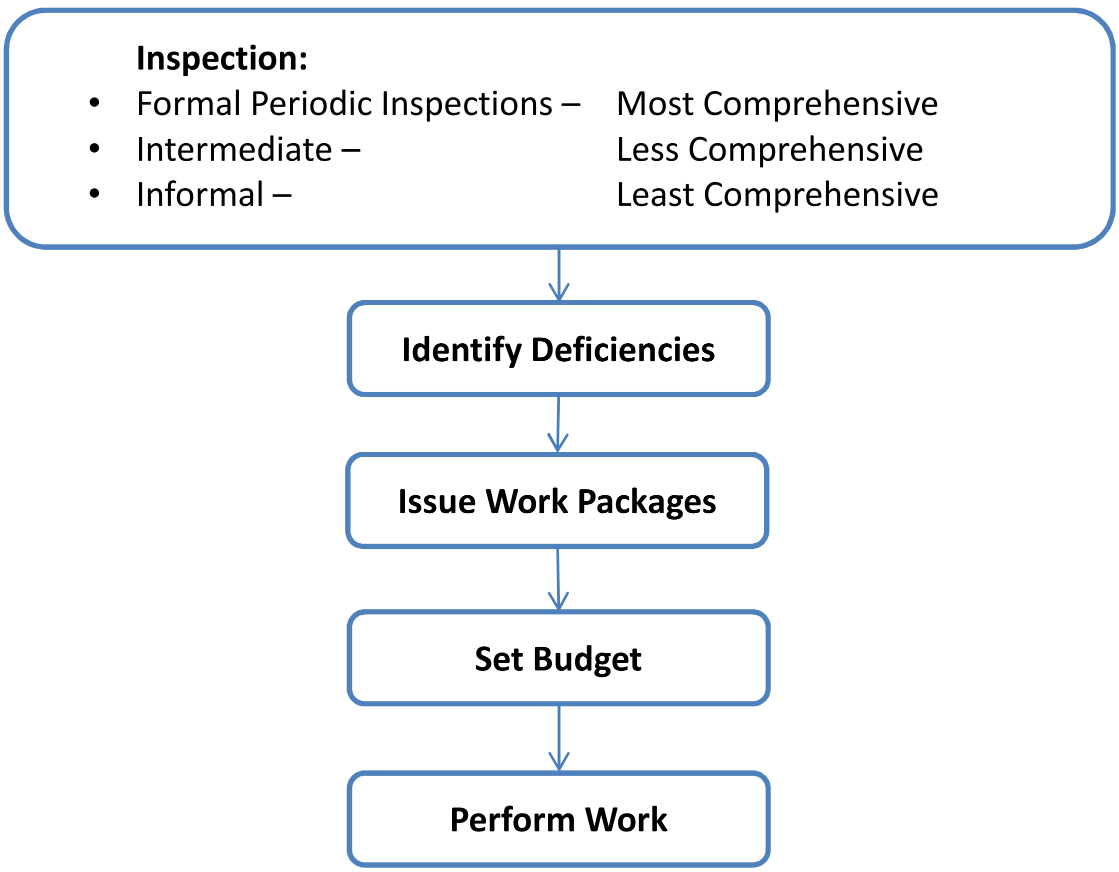


Figure 2.3 Job Jar Infrastructure Asset Management Approach

Inspections are typically triggered by calendar events, such as scheduled annual inspections, unplanned events, such as earthquakes or fires, and as a part of local maintenance programs such as Preventative Maintenance programs (Engineers 1995). Inspections may be categorized as formal, intermediate and informal inspections.

Inspection frequency can vary. Although annual inspections are recommended in the literature, several factors including cost constraints and required amount of details affect the selected interval (Singh and Hegazy 2005). Engineer Regulation 1110-2-100 (Engineers 1995) states that inspections should be done at least once every five years. Exceptions may occur under extreme conditions, such as very costly dam dewatering inspections (Uzarski et al. 2009).

2.5 Infrastructure Inspection Challenges

Poor asset maintenance coordination is affected by factors including the high costs of performing regular inspections and inadequate inspection information. Thorough training is required to prepare inspectors for inspection assignments regardless of whether inspections are contracted out or performed by regional inspectors. The National Center for Education Statistics of America suggests having inspection teams rather than individual inspectors for facility inspections in order to produce better results. Additionally, it is recommended a person who has intimate knowledge of the facility in question, such as a custodian or an internal maintenance personnel member accompany the inspection team (Hegazy et al. 2008).

The inspection process involves the assessment of many aspects that affect the overall performance of a facility. Sustainability, level of service, safety and security as well as other objectives all contribute to the overall performance of an organizational division (Hegazy et al. 2008). Furthermore, the importance of each of those objectives varies with the components being assessed. Having a system that takes into account all of those objectives collectively can result in an even more tedious and costly assessment process, while considering the overall condition of assets alone ignores significant data that affects the overall performance of the facility. The outlined costs and complexity of inspections can be seen in inspection management systems that are examined further in chapter 3.

Despite the high complexity of the inspection process, assets may not always require many of the details that are collected (Engineers 1995). The level of required details depends on the decision level, as network level decisions require less detail, while project level decisions require more details. The level of details also depends on each individual component. For instance, reparable components require timely inspection information with a good amount of details for repair cost and time estimates, while replaceable components require details only about expected or actual failure. Critical components require detailed inspections more frequently because of the high risks associated with component failure.

The complexity of the inspection management process and the lack of funding are compounded by economic and political complications in fund allocation infrastructure maintenance (Mirza and Haider 2003). Scarce infrastructure maintenance funding results in more costs later. The Law of Fives by De Sitter (1984) states that if maintenance is not performed on time, then repairs equivalent to five times the original maintenance account becomes required. If those repairs are not performed, then renewal expenses will equal five times the initial repair costs. Poor maintenance therefore leads to a positive feedback loop that inevitably increases overall costs and contributes to the maintenance backlog issue and deteriorating infrastructure.

2.6 Condition Assessment

Condition assessment provides a method to determine required maintenance and future needs. It is defined as a "vehicle for producing a complete inventory of deficiencies in a facility by thoroughly assessing the existing physical conditions and functional performance of buildings, equipment, utilities, and grounds" (Strong 2004).

Whether carried out by individuals or teams from internal facility staff or outside inspectors, it is essential that inspectors have a thorough understanding of building components and adequate training to perform the condition assessment (Hegazy et al. 2008). Internal resources that accompany the inspection team must also be intimately familiar with the facility, such as a custodian or permanent maintenance staff member.

2.6.1 Existing Condition Assessment Systems

In the past decade or so, asset maintenance evolved from being an art that depends on personal experience and individual ability and knowledge of a system into a science when organizations realized the need for a better asset management process (Uzarski et al. 2009). Several well-established asset inspection management systems are examined as well as newer programs and applications to investigate the benefits and drawbacks in order to develop a system that combines the capabilities of said systems and identify necessary improvement areas. Most notably, US Army Corps of Engineers developed a number of building inspection management systems and services (USACE 2011), including BUILDER, which will be examined in this research because of its widespread use and prominence in the building inspection management field. ReCAPP by Altus will not be independently reviewed despite its prominence due to its the acquisition of VFA to the Altus Group on July 6th, 2012 (VFA 2012).

An emerging technology that is also considered in this research is the portable device and smartphone applications, such as Apple mobile products including iPhone and iPad applications. Table 2.2 provides a list of several asset management and inspection management applications available at the App Store (Apple 2012).

Table 2.1 Desktop Inspection Applications

(VFA 2012)	VFA.facility	Capital planning and management software that allows monitoring the condition and sustainability information about facility assets.
(Marrano and Grussing 2010)	BUILDER	Web-based decision-support tool by US Army Corps of Engineers for building maintenance that uses modules such as ROOFER and is being extended for use by
(USACE 2011)	USACE Engineer Management Systems (EMS)	A collection of Facility Management Systems and complementary developed by the US Army Corps of Engineers including BUILDERTM, Micro PAVER, RAILER, ROOFER, SCALER Corrosion Mitigation and Management Systems and Water-Piper (W-Piper).
(Solutions 2009)	RECAPP	(Renewal Capital Asset Planning Process) Support for data gathering and reporting for audit clients including funding levels and priorities
(ARCHIBUS 2012)	Archibus	Solution system that offers several aspects of real estate, infrastructure and facilities management including Condition Assessment and Asset Management.
(VisionFM 2011)	VisionFM	A visual system that integrates CAD features and allows for document attachment and report generation for facility management.
(Engineers 2005)	DSPMT	Dam Safety Program Management Tools is a desktop program for national dam assessments and data collection.
(Administration 2007)	FEM	Facility Equipment Maintenance “FEM is a computerized maintenance management system that facilitates planning and documentation of operation and maintenance activities and costs by equipment or industrial systems.

Table 2.2 Mobile Device Inspection Applications

Application	Description
ArcSSET.net	A web-based asset management system that uses RFID tags, wireless Windows Mobile data collector, GIS mapping, picture data, email service and online Software as a Service.
GeoJot	GPS-Photo link-based system for mapping and inspecting assets with “Share” options through email or central download point.
iAsset	GIS inspection management system that allows users to record details about assets including the condition, area and category.
EZMaxMobile	A system for creating work orders utilizing photos, details and barcode recognition.
GPS Photo Report	A simple report system that uses GPS technology to generate photographic reports via email.
SmartInspection	A checklist system that may be used on-line or off-line with the option to synchronize later and uses GIS and photo integration.
Allinspections	Cloud synchronization application that features use of GIS mapping, an inspection scheduling system, photo integration and reporting features. It is specialized for certain areas including residential inspections, roof inspections and wind mitigation inspection.
Onsite: AEC	Inspection system that allows data import from BIM (building information model) files and allows for audio recording and photo capture as well as comments, printable reports and email reports. It also uses GPS coordinates of pictures taken.
InspectorApp	Clean text-based inspection that features a color-coded condition assessment.

2.6.2 Condition Assessment Systems Comparison

Table 2.3 shows some of the features for a number of the most well-known programs and applications available for asset management.

Table 2.3 Inspection Application Feature Comparison

		BUILDER	VFA	Archibus	VisionFM	DSPMT	ArcSSET.net	GeoJot	iAsset	EZMaxMobile	SmartInspection	AllInspections	Onsite: AEC	InspectorApp
Platform	Available Online	√	√	√	√		√	√		√	√	√	√	
	Available Offline		√	√	√			√			√	√	√	√
	Desktop		√	√	√			√						
	Mobile		√	√	√		√	√	√	√	√	√	√	√
Audio and Visual Tools	2D Model			√										
	3D Model			√										
	Able to Define Custom Spaces													
	Audio												√	
	CAD Support	√		√	√									
	GIS Mapping	√		√			√	√	√	√		√	√	
	Mark on 2D/3D Model				√									
	Mark on Pictures							√			√	√	√	
	Take Pictures	√						√	√	√	√	√	√	
	Record Video													
Interface	Assign Jobs to Inspectors			√			√				√	√		
	Hierarchy & Reporting Levels	√												
	Condition Assessment	√	√	√	√				√	√				√
	Condition Prediction	√	√	√	√									
	Customizable Surveys		√								√			
	Other Assessments	√		√										
	Per-Component Condition History	√					√							
	Picture Condition Guide													
	Text Condition Guide	√	√	√										

Well-established inspection management systems such as BUILDER and VFA provide powerful tools and components that give users insight about asset conditions and contain knowledge bases that provide guidance into the inspection process, although an implementation of a picture-based knowledge base is needed. However, in order to increase the effectiveness of those systems, technologies that are emphasized by mobile inspection applications, such as pictorial inspection link to inspection data must be considered. Mobile applications feature intuitive interfaces and use of mobile device utilities effectively, such as audio memos and automatic GPS tracking, but often lack the sophistication and capabilities available in well-established asset inspection management systems.

2.7 Important Features Related to Inspection Management

Certain tools and features are recommended to improve the assessment process. The following visual aid tools are aimed at reducing subjectivity and producing better reports capable of location referencing:

1. **Geographical Information System (GIS)**: The inclusion of a GIS can have a huge impact on management decisions and understanding of assets that may be scattered over a large geographical area (Hegazy 2010). Demographic information may include budget distributions and condition information and is very useful during the reporting process. GIS integration also allows inspectors to visually view new assignments and perform inspections by area, reducing efforts and increasing productivity.

Further investigation suggests that factors that contribute to building deterioration are linked to school size, demographics and location (Ahluwalia 2008). Overpopulated schools tend to deteriorate faster due to overuse, while secondary schools tend to have higher rates of deterioration due to vandalism and accidental damage. Schools are also affected by the location, such as neighborhood effects on rates of deterioration due to factors such as crime rate, unemployment rate and income level. The GIS is recommended to make a connection between location data and facility maintenance data in order to support better informed maintenance decisions.

2. **Visual Referencing**: As established earlier, inspection subjectivity can be very harmful to management maintenance decisions as inspection results depend deeply on inspectors' personal judgment and experience. While qualified inspectors can have excellent insight into asset condition, their perception of 'critical' vs. 'poor', for example, can differ, which affects fund allocation and maintenance priorities. A number of existing systems include textual description databases that help inspectors make consistent component assessments. However, having a visual reference in addition to the description for each component provides a much stronger basis for consistent judgment.
3. **3D Computer-Aided Design (CAD)**: Many buildings have drawings that are stored as CAD, a technology that has been an industry standard for some time (Ahluwalia 2005). CAD files information may be projected from the traditional 2-

dimensional drawings into 3-dimensional drawings by adding a constant height to generate 3D models. Adapting CAD files as the source of spatial data is done for the availability of those files and to simplify the conversion process. It is also done to reduce the amount of resources that would otherwise be invested to convert the files through different formats.

4. **Efficient Building Hierarchy**: A structured component and organization hierarchy needs to be considered for the inspection management system. Uniformat II is a standard building structure that classifies building elements and related site work that has been recommended by the Construction Specifications Institute/Construction Specifications Canada (CSI/CSC) to structure schematic specifications and by the Design-Build Institute of America for performance specifications (Charette et al. 1999). It is also being increasingly used in projects as a universal standard in North America. Component classification is a hierarchy of four levels; Major Group Elements, Group Elements, Individual Elements and Sub-Elements.

Furthermore, components need to have different impacts on the assessment based on factors such as criticality and risk of failure (Uzarski et al. 2009). Index values are assigned to have different impacts of components on the results of assessments. Component impact on the overall assessment is calculated by multiplying the overall component performance by its relative importance factors:

$$\boldsymbol{Component\ Rating = Component\ Performance \times Relative\ Importance} \qquad \boldsymbol{Eqn\ (2.1)}$$

2.8 Conclusions

Several improvements to existing inspection management systems that enhance asset management by providing more visual, structured inspection data, namely, features such as GIS, visual referencing, 3D CAD, efficient building hierarchy and flexible survey design. There is a need for an inspection management system that combines those enhancements to provide a structured, mobile and visual assessment process.

Chapter 3
Building Inspection Challenges and Needs

3.1 Introduction

This chapter examines the necessary specifications of a system for an efficient inspection management system. It begins by presenting a field study of inspection practices at the Toronto District School Board (TDSB) in order to highlight the inspection challenges it encounters. Then, it details some of the relevant requirements of a recent Request for Proposal (RFP) for a 5-year Condition Assessment Program for the Ministry of Education in Ontario that was valued at $20.6M, awarded in January of 2011 (MERX 2011).

3.2 Toronto District School Board Inspection Challenges: A Field Study

A field study was undertaken at the Toronto District School Board (TDSB) to highlight the challenges in the building inspection process. The TDSB is the largest school board in Canada and the fifth largest in North America. It administers close to 600 schools and spends $50M annually for a capital renewal program. TDSB divides the Toronto area into four regions according to geographical location, each containing six school families of about 24 schools, each, as seen in Figure 3.1. Schools are identified by school ID, family, type, construction year and cost, and address.

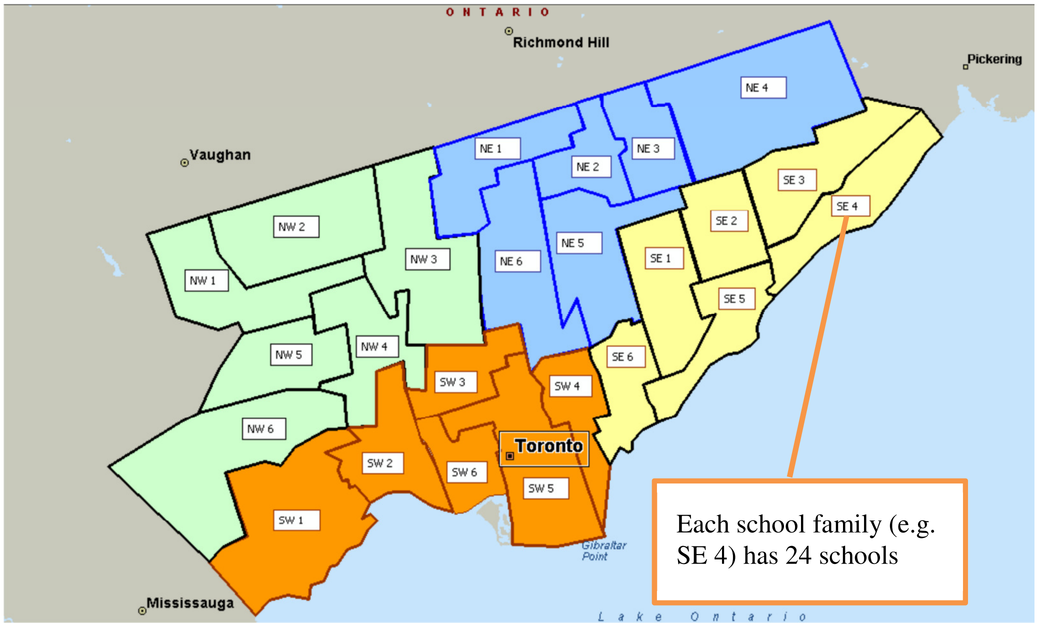


Figure 3.1 TDSB Regions and Families of Schools (Hegazy et al. 2008)

TDSB schools are aging and their conditions are deteriorating. In 2005, 59% of the schools had an overall ‘poor’ condition index and 26% had a ‘critical’ condition index with an average age of 44 years and a median of 56 years. Over 90% of the schools were over 50 years old. As school asset conditions are still deteriorating and maintenance budgets are limited, it is essential to identify and prioritize asset maintenance through effective inspection.

The TDSB Facilities Management Department, which administers annual capital renewal projects with an annual budget of $50 million, uses computerized asset management software ReCAPP to perform maintenance through a repair-based strategy. The software requires performing detailed deficiency-level inspections for all building components (Ahluwalia 2008).

The high costs of asset management caused the TDSB to downsize its Capital Renewal Section, affecting in-house maintenance personnel's ability to perform regular inspections to identify critical items in a timely manner. Costly inspections are therefore outsourced by the TDSB every few years. Approximately three years are required to visit each building at least once. Inspection results are, however, subjective as many components may have the same rating despite some being in worse conditions than others (e.g., many windows may be in 'poor' condition).

The field study at the TDSB had two procedural steps, as follows:

1. *Site Visit to Five Sample Schools:* During the site visits, data collection was done on spreadsheet software with a generic checklist of building components on a laptop computer. First, the caretaker was questioned about any components in critical condition, and the answers were recorded in text format. Pictures were also taken using a digital camera in the order of the inspector's visit, and were not connected with any of the descriptive observations. The site visit to each school took approximately four hours.

2. *Data Entry in the Office:* After performing each site visit, the inspector entered data that could not be completed on site. The inspector also uploaded digital photos onto a designated school board computer. Components were re-assessed by the inspector at the office according to observations and photos taken during the site visit as the inspector relied on memory to recall the path and observations made during the site visit. Data was then manually entered

into the RECAPP system. It was estimated that each hour in the field mandates three hours in the office. Accordingly, it took a few days to enter the data of one school into the system.

Based on the field study findings, the following observations were made that affect inspection cost and efficiency (Ahluwalia 2008).

1. A direct ranking is recommended with a good quantification method.
2. No standard list of components was used, and inspectors manually change components as they encounter them during their site visits. A standardized list of components is recommended.
3. Historic condition data is not preserved as new inspection data erases old data. Historical data needs to be saved for reference.
4. Component locations are not saved and are only defined manually on printed plans with no link to component pictures. The study suggests a simple method for marking components on reusable digital floor plans.
5. Inspections are performed in a highly subjective manner. A pictorial database is recommended to be available to inspectors during assessments.
6. There is a general lack of automation causing a lot of costly manual work, such as re-entering data in the office. On-site data entry greatly reduces manual work.

Based on the site visit, the basic required features in the proposed inspection management system are:

1. Introduction of a visual guidance system in the form of a pictorial database of components in different condition states to reduce inspection subjectivity.
2. Design of a simple visual method of marking component defects directly on 2D and 3D floor plans to simplify and speed up inspections while providing a visual location reference for problem areas.
3. Capture of photos directly from hand-held devices and allowing inspectors to annotate pictures with comments.
4. On-site inspections that do not require re-entering data into different systems. Automatic synchronization with the central database then allows inspection information to be transferred directly between administrations and inspectors to save time and reduce costs.
5. Production of chronologically connected reports with component picture referencing and GIS and 3D location referencing.

In addition to the above requirements, recommendations have been identified based on the recent Ministry of Education bid for inspecting all Ontario schools, which will be presented in the following section.

3.3 Ontario Ministry Bid for School Inspection

The Ministry of Education owns approximately 4,000 elementary schools and 900 secondary schools that are administered by 72 school boards in Ontario. The schools operate an approximate area of 26 million square meters of space. An annual budget of about $300M is allocated for capital assets maintenance and renewal in addition to temporary funding provisions such as Good Places to Learn. The Ministry of Education prefers to perform inspections on a five-year cycle. The amount of inspections performed is measured by the gross floor area annually inspected. The list of the schools is not fixed each year, as about 55 schools close their operation annually, while about 66 new schools open for operation annually.

In 2010, the Ministry of Education issued bid documents and call for bidders to inspect all their schools over a five year period, in addition to developing a detailed inspection management system. As part of the bid documentation, the Ministry of Education provided the following information that system developers should consider:

1. Facility Data.
2. Component Information.
3. Examples of Ratings Systems.

The following subsections present the information included with the bid package, which have been considered as necessary specifications in designing an effective inspection management system.

1. **Facility Data:** This is a list of all in-scope facilities that are to be assessed for the Ministry. Facilities are listed by Region and School Board showing the number and total area of administrative, continuing education and school facilities. Facilities are separated by age depending on whether they require a New Facility Condition Assessment or a Full Condition Assessment as summarized in Appendix A. Facility site and floor plans are also made available in order to familiarize inspectors with inspection sites and improve their efficiency. Available database information also contains facility Core Data, which is a set of mandatory fields containing education facility basic information such as Campus ID and Opening and Closing Dates and is made available for the assessment team. Additionally, the Ministry provides the best available information on Education Facilities annually including school age, description and location.

2. **Component Information:** This is a list of in-scope Components. The list follows a modified version of the standard Uniformat II list of components that is relevant to in-scope sites and facilities. Components are classified based on applicability to a New Facility Condition Assessment or a Full Condition Assessment, as listed in Appendix B.

3. **Examples of Ratings Systems:** Examples of a component condition rating system was provided, which classifies component conditions as Excellent, Good, Fair, Poor, or Defective, as explained in Table 3.1.

The bid document also specifies a rating system for project repair recommendation, classifying project repair recommendations as Repair, Replacement, Study Recommended, or Invasive Testing Recommended, as shown in Table 3.2.

Table 3.1 Component Condition Rating System

Rating for Components		Definition
A	Excellent	Functioning as intended; as new condition; limited (if any) deterioration observed.
B	Good	Functioning as intended; normal deterioration observed; for most infrastructure assets, this implies that no repairs are anticipated within the next five (5) years.
C	Fair	Functioning as intended; normal deterioration and minor distress observed; minor repairs will be required within next five (5) years to maintain functionality.
D	Poor	Not functioning as intended; significant deterioration and distress observed; significant repairs required, within the next five (5) years to restore functionality.
E	Defective	Not Functioning as intended; significant deterioration and major distress; major repair or replacement required to restore function.

Table 3.2 Possible Repair Recommendations

Project Recommendation	
Code	**Definition**
R1	Repair
R2	Replacement
S	Study recommended
I	Invasive testing recommended

3.3.1 Deliverables and Requirements

In addition to the basic features and specifications obtained earlier based on the field study at the TDSB, all deliverables and requirements mentioned in the Ministry of Education bid have been considered as part of the necessary specifications in the proposed inspection management system of this thesis. Basically, an essential component of the RFP is to develop a facility assessment software application to be used in inspecting all the schools. The application has to have all the provisions and flexibility to consider different schools (with their GIS locations, detailed school plans, and hierarchy of building systems, etc.), school boards, dynamic inventory, and all data about the history of inspections and related performance assessment. The following items outline major deliverables and requirements as outlined by the Ministry of Education for the application:

1. Facility Information including Core Data and additional Facility Fields.
2. Component Condition Assessment recording the component condition, component fields and component photos.
3. Project Information for renewal projects and additional Project Fields as well as the ability to review past Renewal Work.
4. Report generation using various criteria.
5. Energy and Accessibility Checklists.

The detailed requests of the five deliverable categories are as follows:

1. **Facility Information:** The facility assessment application is an update of the existing Ministry of Education's maintenance management program. Using

the existing data, the Ministry wishes to transfer the existing data, including 'Core Data', which are standardized, descriptive data fields that are mandatory for Educational Facilities as shown in Table 3.3. The application is required to incorporate Core Data fields into the system by providing compatible database entries that allow importing such data from the previous application.

Table 3.3 Facility Core Data Fields

• School Name	• Opening Date
• SFIS # (school number)	• Closing Date
• Street Address	• Grades served
• City	• BSID #
• Postal Code	• Campus ID #
• Panel	• School Foundation ID #
• Status (Open/closed)	• Board Facility #
• ADE	• Ownership (owned/leased)
• NPP capacity	• Size of site (hectares)
• OTG capacity	• Year built by original/additions
• GFA (m^{2})	• Gross floor area by original/additions
• Non permanent structure info :	• Building Identification Number (This number is new and will be generated by the Ministry.)
○ RCM units	
○ Portable units	
○ Portapak units	
○ Non-permanent RCM units	
○ Non-permanent GFA m^2	

In addition to Core Data fields, which do not change, the following editable additional Facility-Related Fields are required:

- Number of building stories
- Is there a Compliant with Accessibility Customer Service Standards
- Is there a Compliant with Accessibility Built Environment Standards
- Energy Audit existence and date
- Accessibility Audit existence and date
- Ministry facility assessment dates
- Asset replacement cost for each facility (generated by Ministry formula)
- Heritage designation
- Asset ID number
- Has Air Conditioning
- Has Mechanical Ventilation
- Is Wheelchair Accessible
- Pre-2010 PTR designation
- School Contact Info: Name, Phone Number, Email
- Board-identified School Family or Group ID
- Ownership fields (Including permanent and temporary buildings and co-ownership etc.)

Finally, the overall Facility Condition Index (FCI) is calculated as follows:

$$FCI = \frac{Renewal/Replacement\ \ Needs\ (based\ on\ 3\ or\ 5\ years)}{Repalcement\ Cost\ (as\ determined\ by\ Ministry\ guidelines)} \qquad Eqn\ (3.1)$$

2. **Component Condition Assessment:** Component condition assessments are performed on components to collect component condition, component information fields and photos. The number of components assessed depends on the type of condition assessment to be carried out, which depends on facility age. Facilities that are at least 8 years old will undergo a *Full Condition Assessment*, whereas facilities that are 5 to 7 years old will receive a *New Facility Condition Assessment* as outlined in Appendix B. Facilities that are less than 5 years old will be exempt from assessments.

Component conditions are collected by performing a non-invasive visual assessment by inspectors. Inspections focus on major components and target repair, renewal and replacement projects in excess of approximately $10,000. Inspectors are only responsible for the components that they are assigned, but are required to take notes of additional important sightings such as building code violations or unlisted components should they encounter them. The following minimum information is to be collected about each of the in-scope components:

- Description
- Age or installation date
- Model number and serial number for mechanical and electrical equipment
- Remaining useful life estimate
- Other information to support renewal and further study recommendations, such as costs and methods

Components will have different impacts on assessments based on their importance as outlined by the following criteria:

- Operational importance to component or facility
- Component rate of utilization
- The effect on operation in case of unavailability
- The impact on other components if damaged or unavailable

In addition to descriptive component conditions and ratings, digital photographs are required to supplement component condition and recommended maintenance. Photos are required to be dated and annotated. *Table 3.4* summarizes the minimum requirements for photos.

Table 3.4 Minimum Component Photo Requirements

Component	**Details**
Exterior	North, South, East, West elevations
	Visible address and school name
	Exterior building and site defects
Heating Systems	Rooftop units
	Boilers and auxiliary systems
	Other significant components
Air Conditioning Systems	Rooftop units
	Centralized components
	Other significant components
Transformers	
Inverters	
Doors	
Windows	
Defects	For applicable components as applicable

It is also important to note conditions and circumstances affecting Condition Assessments. Facility assessments scheduling will be affected by several factors and conditions including the following:

- An equal percentage of educational facilities are assessed annually. For a five year assessment cycle, 20% of facilities are to be assessed each year.
- Within the first two years, all School Boards will have some educational facilities assessed.
- School Boards may have schools assessed over two or three non-consecutive years based on factors such as school size and locations.
- Geographical considerations are to be taken in order to minimize travel time and costs.
- Weather may affect the ability to inspect certain schools or areas, such as snow-covered roofs.
- Staffing and operational limitations may prevent the ability to perform assessments, such as summer schedules for certain educational facilities or start-of-term periods.
- Accommodations of requests and recommendations by the Ministry of Education may also affect assessment scheduling.

3. **Project Information:** In addition to assessing components, the request for proposal requires that inspectors make recommendations for repair, renewal and rehabilitation work. It is also required that inspectors revisit certain past

renewal projects. The following minimum information is to be collected about renewal projects:

- Description
- Justification
- Project cost estimation
- Classification by:
    - Recommendation type
    - Priority
    - Expenditure type
    - Funding

Repair and renewal projects are to be prioritized based on component conditions, and influenced by the following criteria:

- Component importance to site or building
- Component condition
- Urgency to continued operation

4. **Report Generation:** In order to use the collected data efficiently, the Ministry requires reporting specifications that include at least the following information:

- Facility, site and systems description including Core Data and other fields
- General comments on major building systems
- Component conditions
- Component renewal recommendations including prioritization as determined

by the application over the next 25 years

- Additional studies, investigations and destructive testing recommendations where believed necessary for additional information about renewal needs and remaining useful life
- Digital photographs
- Facility Condition Index

Progress reports are also required during mandatory monthly meetings between the Ministry of Education and the application supplier. Reports will indicate assessment status including prioritized project-related issues and mitigation strategies. Additionally, the application will be evaluated based on its capability to provide user-defined reports that comply with the fields in Table 3.5.

Table 3.5 User-Defined Reports

By School	By Component	By School Board
Facility condition	Renewal needs/costs per component	Renewal needs/costs per component category (mechanical, electrical, etc)
Renewal needs/costs	Events - variable time frame	Events – variable time frame
Events - variable time frame	Multi-year comparisons	Renewal need forecasting based on investment level
Multi-year comparisons		Multi-year comparisons

5. **Energy and Accessibility Checklists:** In addition to the main Component Condition Assessment, an Energy and Accessibility Checklists are outlined. The checklists are not audits, and only cover a checklist of accessibility and

energy related components and equipment that can be identified visually or based on school documentation. The Energy checklist assesses the compliance of facilities to the following items:

- Has an Energy Audit been undertaken on the facility
- Does the facility have
    - High efficiency boilers
    - High efficiency water heaters
    - Ventilation energy recovery
    - Improved insulation
    - Variable speed drives
    - High efficiency light systems
    - Building automation systems
    - Low energy window and door systems
    - Low roof R value
    - Tinted south and west windows
    - Damper systems
    - Low-flow plumbing systems and fixtures

The accessibility checklist is composed of a list of items that measure a facility's overall accessibility performance as follows:

- Availability of clearly marked accessible parking.
- The presence of loading zone for accessible vehicles.
- An accessible pedestrian route is available from the parking lot to an accessible building entrance.

- Accessible building entrances are clearly marked.
- The width of accessible entrances is at least 0.85m.
- All floors are accessible.
- Elevator doors are at least 0.9m wide and long enough to accommodate people using accessibility devices.
- Braille signage, controls and emergency call systems are easily accessible from a seated position in elevators.
- Elevator cars have audible signals that announce floors and travel direction.
- All instructional space is accessible with doors that are 0.85m wide or more.
- Fire policy and safety plans are designed for evacuation of people with disabilities.
- Main exit routes and doors are easily accessible by people using mobility aids.
- Fire alarms have audio and visual signals.
- Mobility devices accommodate washroom access for each sex.
- At least one washroom exists on each floor that has the following features:
    - Grab bars
    - Coat hooks
    - Flush controls
    - Wash basins
    - Toilet water dispenser
    - Emergency call button
    - Mounted hand-dryers or paper towel holders
    - Automatic or lever handled faucets

3.4 Conclusions

The requirements of the Ontario Ministry of Education RFP and the field survey for the Toronto District School Board emphasize the need in large owner organizations for a visual, flexible inspection-management system. A visual guidance system to increase consistency is also necessary. As highlighted by this chapter, a direct link between inspection data and a pictorial record of the condition of assets is important for asset repair, renewal and replacement decisions. Finally, location-based referencing to inspection data is essential for identifying problem areas without exerting excessive manual labor. The improvements to the inspection process will greatly reduce costs, and make the inspection process more efficient.

Chapter 4
Inspection Management System for Buildings

4.1 Introduction

This chapter presents an assessment system that complies with the requirements of the Ministry of Education and the findings of the Toronto District School Board field visit. The inspection management system aims to streamline and efficiently structure the inspection process using visualization tools and flexible inspection design.

4.2 Proposed Inspection Management System (IMS)

The proposed inspection management system application has been programmed using the Visual Studio 2010 with Microsoft Entity Framework 4.0, Windows Presentation Foundation (wpf) markup language XAML along with underlying C# programming language. The Windows Communication Foundation (WCF) was used to synchronize data between administrators and inspectors. The program development was carried out over a period of one year. The application contains about 25 user interface windows and a number of support classes, including custom classes for data abstraction and handling, customized user interface, imported modules for map, camera and 3D modules, as well as customized wpf controls. To give an idea about the depth of the system, Table 4.1 highlights some of the metrics that the programming environment calculates. As shown, the two parts of the prototype application (inspection and database) involve about 18,000 lines of code.

Table 4.1 Inspection Application Code Metrics

Property	Application Project	Data Project
Name	Facility Inspection	Inspection Data Model
Total Lines of Code	9,950	7,918
Depth of Inheritance	10	3
Class Coupling	761	124
Cyclomatic Complexity	3,456	2,714
Maintainability Index	93	82

The inspection management system application has been designed with three main components: Administrator-side functions, the Database, and Inspector-side functions (Figure 4.1). The administrator functions are defining/modifying organizational structure, facility data and assignments as well as viewing reports. The database serves as the conduit to store and communicate data between administrators and inspectors. The inspector functions, on the other hand, include viewing facility plans and marking defects on the building 3D model, and performing inspection tasks such as responding to assessments and taking pictures.

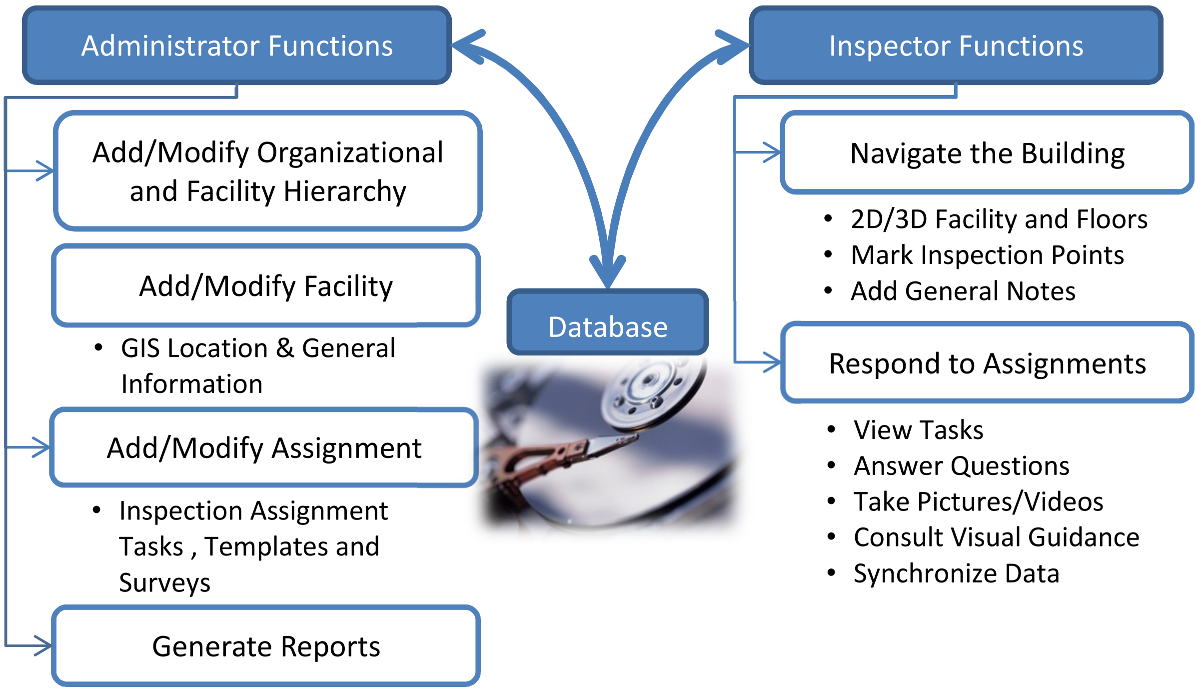


Figure 4.1 Components of the Proposed Inspection Management System

The system has been designed so that any user organization (the one that manages the inspection process and all the data) first defines the asset inventory in the database through the administrative functions. During this step, organizational and facility information is entered, 3D models of all buildings are generated, and various assessment types are designed and assigned to inspectors. Data that has been entered into the database is then synchronized to be received by inspectors. Once assignments are received, on-site building inspections can be performed. Inspectors access the assessment information by accessing the GIS system. The building 3D model that is related to any assigned work is then accessed by inspectors and assessment information based on visual observations is entered. Finally, inspectors synchronize the data to be received at the central database in the office. Accordingly, administrators can view various reports.

4.3 Administrative Functions

The following subsections describe the implementation of the inspection management system's four main functions:

- Specifying the organizational and facility hierarchy
- Creating/Modifying Facility Information
- Creating Assignments, Assessments and Surveys
- Generating Reports

4.3.1 Specifying Organizational and Facility Hierarchy

In order to implement a structured system that is flexible enough to accommodate most large organizations, the system uses a two-level organizational and facility hierarchy:

1. **Organizational Hierarchy**: Based on Ministry of Education organizational specifications discussed in Chapter 3, buildings are classified by school board to follow the Ministry's organizational structure, such as geographical school families and types (e.g. Secondary schools). In order to accommodate this structure, the system classifies facilities by organization

and assigns addresses to each facility as shown in Figure 4.2. Furthermore, facilities may be assigned more than one address to include facilities that have split campuses. Addresses may also belong to more than one facility, which allows shared building sites to be treated as distinct entities. This design is a structured approach for facility classification that can be applied to educational facilities as well as other large organization facilities.

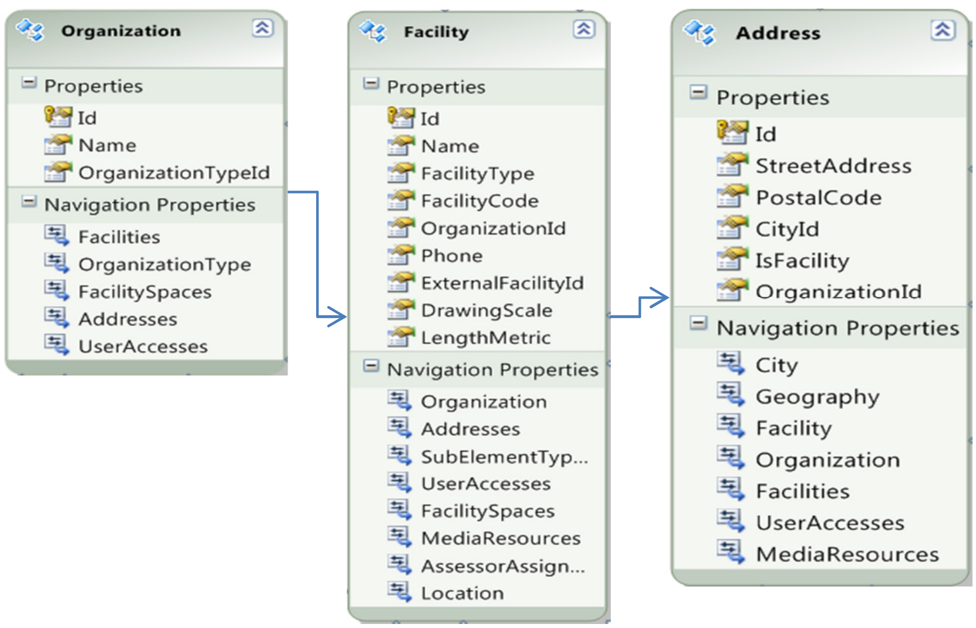


Figure 4.2 Database Tables Related to Facility Information

After specifying the organizational structure, administrators specify facility names and addresses. The system automatically verifies the address using its built-in GIS capability and displays the facility on a map, such as the one seen in Figure 4.3. The main administrator interface shown in Figure 4.3, which presents the administrative functions menu and the organizational and facility hierarchy in one simple screen.

Administrators can navigate using the map to view facility information and inspection data, which adds a visual, geographic aspect to inspection data that supports well-informed asset maintenance decisions.

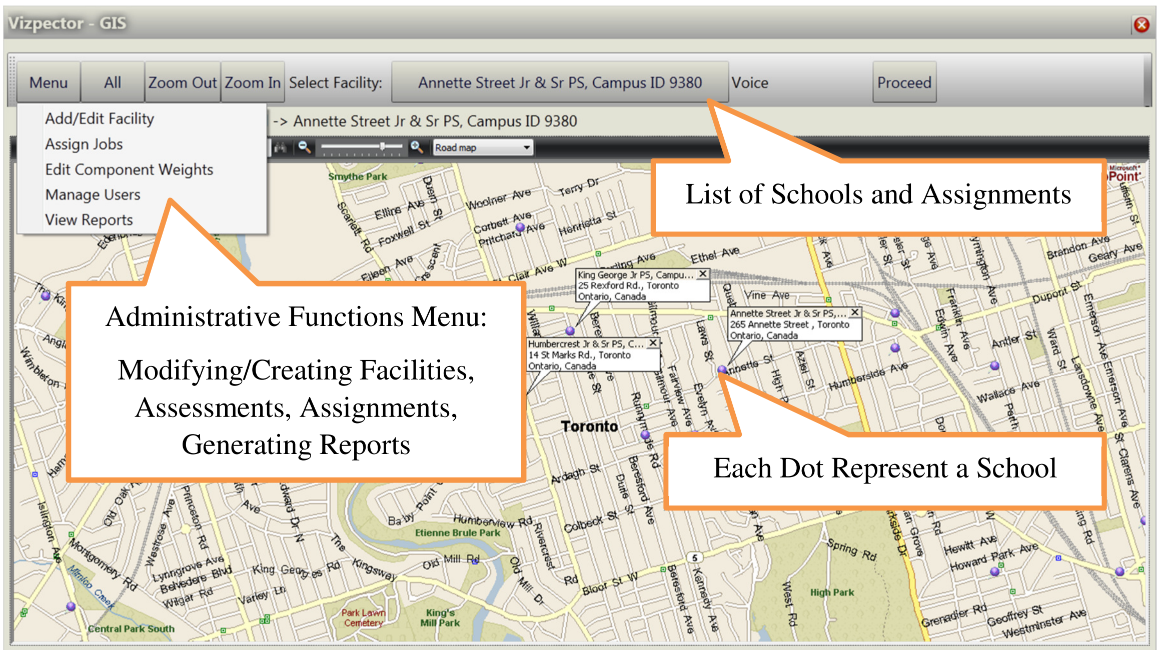


Figure 4.3 Administrator: Main Screen

2. **Facility Component Hierarchy**: Administrators access the second level of the hierarchy to add/modify building components and details. Facility components and systems follow the modified Uniformat II list provided for educational facilities by the Ministry of Education. Changes to the default list may be made as the need arises. Components are stored hierarchically in the database following the four levels of system components provided in Uniformat II and shown in Figure 4.4. The hierarchy levels are the following:

1. Level 1: Major Group Components
2. Level 2: Group Elements
3. Level 3: Individual Elements
4. Level 4: Sub-Elements

At each level (Figure 4.4), a weight field can represent the impact of an item on its parent level. For instance, an Electrical system component can be assigned a higher (or lower) impact on the assessment by assigning a different weight value than the HVAC component. The weighted component system improves asset management maintenance and renewal decisions by prioritizing components based on factors such as importance, cost and impact on the system. Such decision support can greatly improve fund allocation and reduce system failures.

Figure 4.4 Database Tables for the Building Component Hierarchy

4.3.2 Creating/Modifying Facility Information

The second important administrative action is to enter facility and 3D model information. Following the Ministry of Education guidelines (presented in part a. of section 3.3 and Table 3.3); fields for all facility information have been created, including facility name, ID, age and description. Figure 4.5 shows the administrative window for creating/modifying facility data, which is achieved by:

1. Entering general information about a facility and its location (step 1).
2. Creating a full 3D model of the facility through the following steps:
    a. Importing the main facility site plan CAD file and selecting relevant layers (step 2).
    b. Marking building locations on the site plan to define buildings (step 3).
    c. Importing floor CAD files and assigning them floor heights (step 4).
    d. Marking various floor-spaces, such as rooms by selecting and labeling rectangular areas on the floor plans (step 5).

After facility details are entered, facility plans are imported into the system. Due to their widespread usage, the CAD file formats (such as .dwg files) are used as the default source of facility plans as discussed in Chapter 3. Creating a full 3D model of the facility, with its floors and spaces, involves the following five steps that were programmed using a third-party programming toolbox for CAD manipulation:

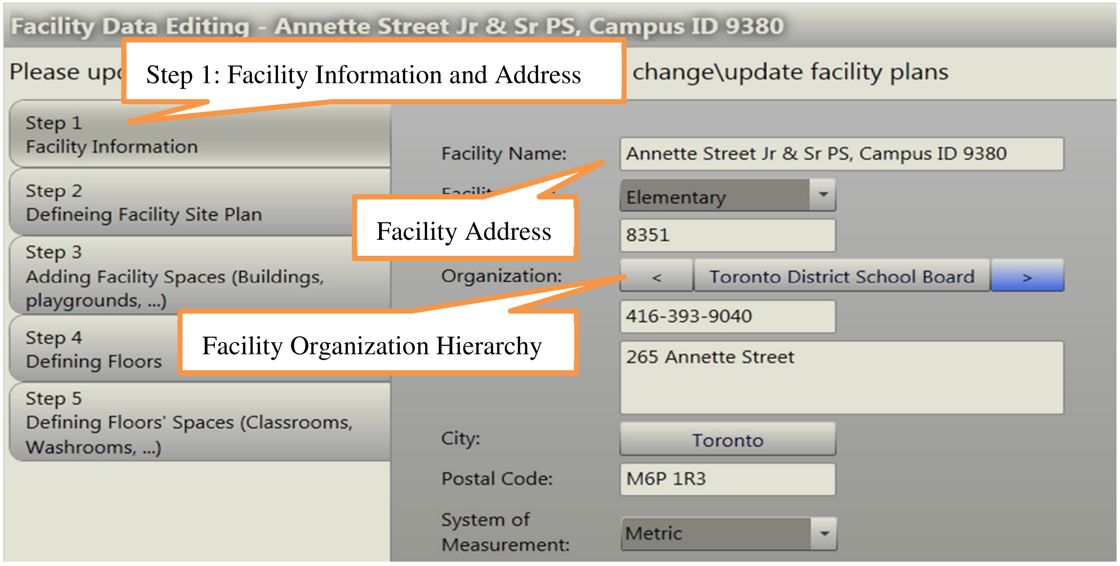


Figure 4.5 Step 1/5 Creating a Facility: General Information and Address

1. *Defining Facility Plan*: A single CAD file is imported to represent the entire facility plan, including all buildings and physical attachments, such as parking spaces as shown in Figure 4.6. In this step also, all unnecessary layers in the CAD file can be turned off.

2. *Defining Buildings (Facility Spaces)*: Each building is mapped to the site plan by marking a location box on the plan. Buildings are referred to as Facility Spaces, which may include non-building entities such as a tennis court, pool, or parking lot. Marking a building on the floor plan is demonstrated in Figure 4.7.

3. *Defining Building Floors*: A single floor CAD file (if any) is added to the building, unnecessary layers are turned off, and the floor is aligned with the facility location on the site plan. The floor height is added, and may or may not be identical on all floors, as shown in Figure 4.8.

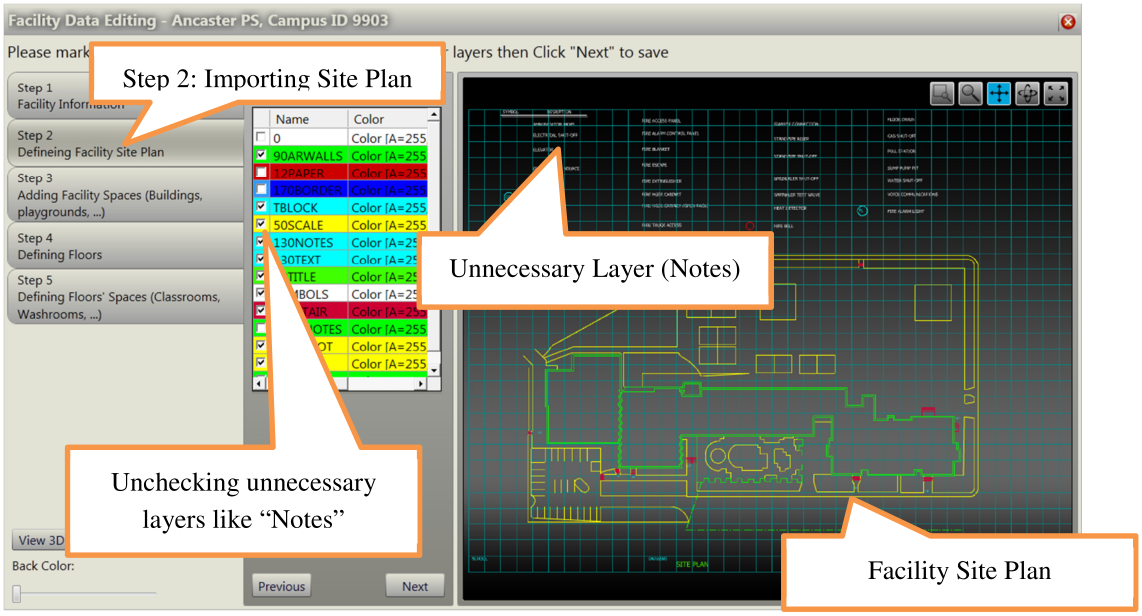


Figure 4.6 Step 2/5: Importing the Site Plan

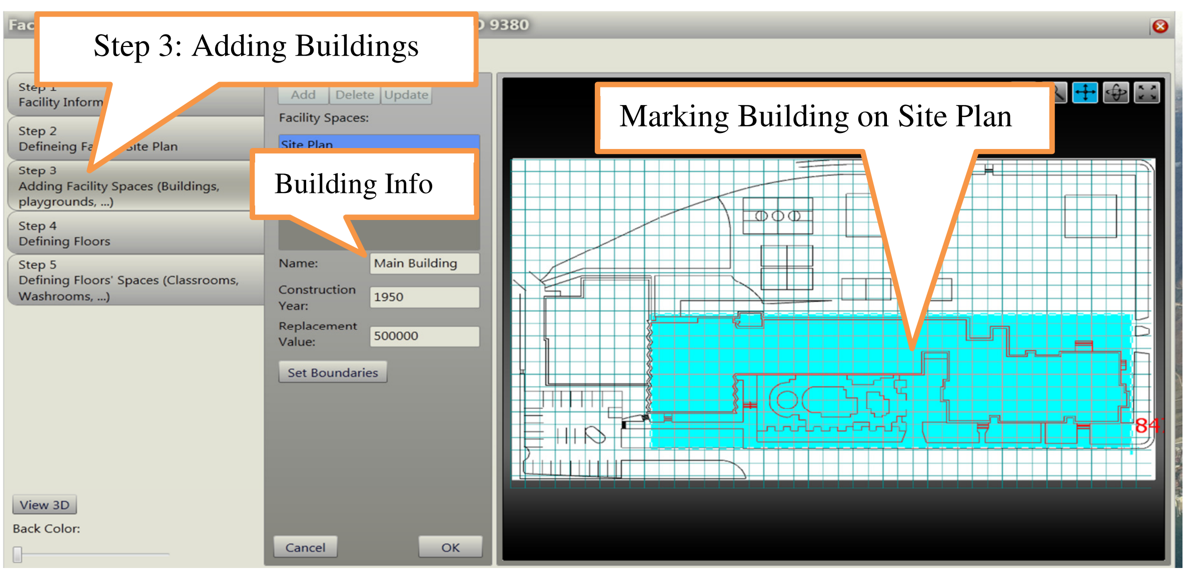


Figure 4.7 Step 3/5 Defining a Facility Space on the Plan

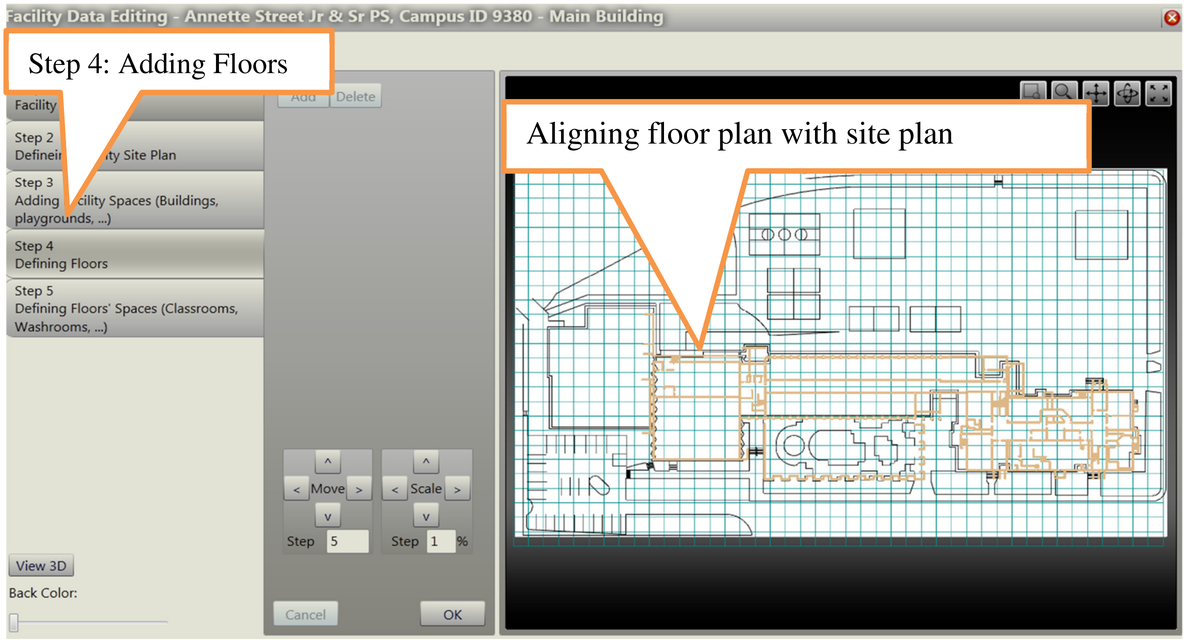


Figure 4.8 Aligning a Floor a Building at the Site Plan

4. *Defining Floor-Spaces*: A single floor-space, which may represent a washroom, custodian room, classroom or even a multiple floor-space (such as a Gym that spans two or more floors), can be easily defined. It is assigned a height of one or more floors, as demonstrated in Figure 4.9.

5. *Repeating Steps 2 to 4 until Finished*: Step 4 is repeated for more spaces; step 3 is repeated for more floors; and step 2 is repeated for all buildings and site attachments until all of the required data is entered.

Creation of the 3D model is done by importing and aligning CAD file drawings, and then allowing the graphics engine to render the 3D model. Figure 4.10 shows an example of a 3D model with 2 floors and some spaces.

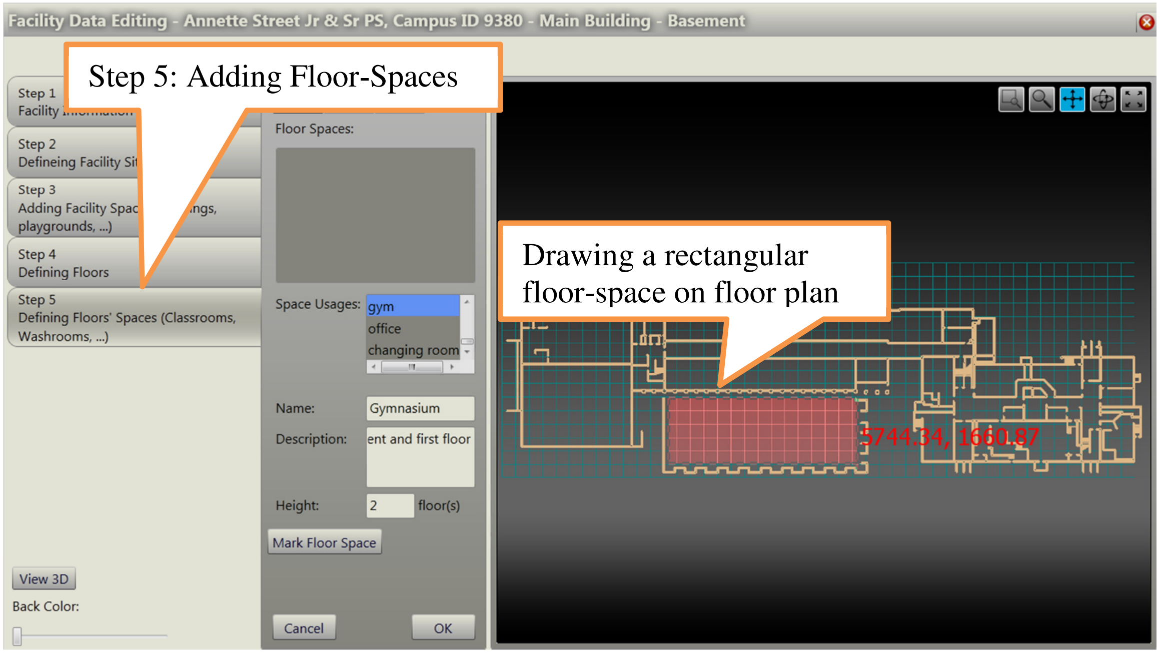


Figure 4.9 Adding Floor-Spaces

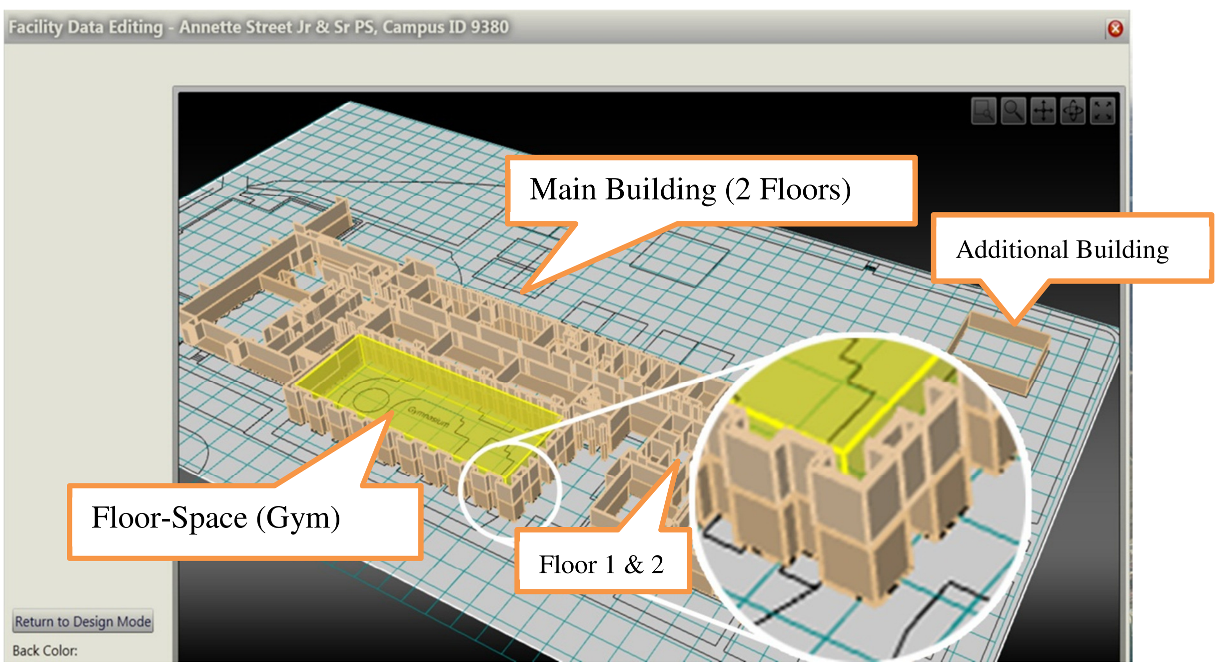


Figure 4.10 3D Facility Rendering

4.3.3 Creating Assignments, Assessments and Surveys

After creating 3D models for the facilities and fine-tuning the component hierarchy, administrators are ready to design assessment types and assignments to be sent out to the inspectors who will carry out the inspection tasks. The requirements in Chapter 3 specify that created assessments should be applicable to different facilities without the need to repeat assessment creation unnecessarily. The system fulfills this requirement by allowing administrators to create inspection templates. An "inspection template" is a reusable entity that contains one or more "requests". For example, a "New Facility Condition Assessment" may be made into an inspection template, which can include specific inspection requests (specific components, specific survey). Energy and Accessibility Audits can also be another inspection template designed for use in the inspection of specific components only.

Besides reusable standard assessments, follow-up site visits were also outlined as a common practice initiated by inspector observations and suggestions. For example, an inspector may need to perform invasive testing after visually identifying possible defects. The proposed system allows administrators to add "custom requests" to an assignment, giving them the flexibility to assign specific tasks.

The top link in Figure 4.11 represents creating a reusable, generic assessment template, which includes one or more tasks, whereas the bottom link represents assignment-specific tasks.

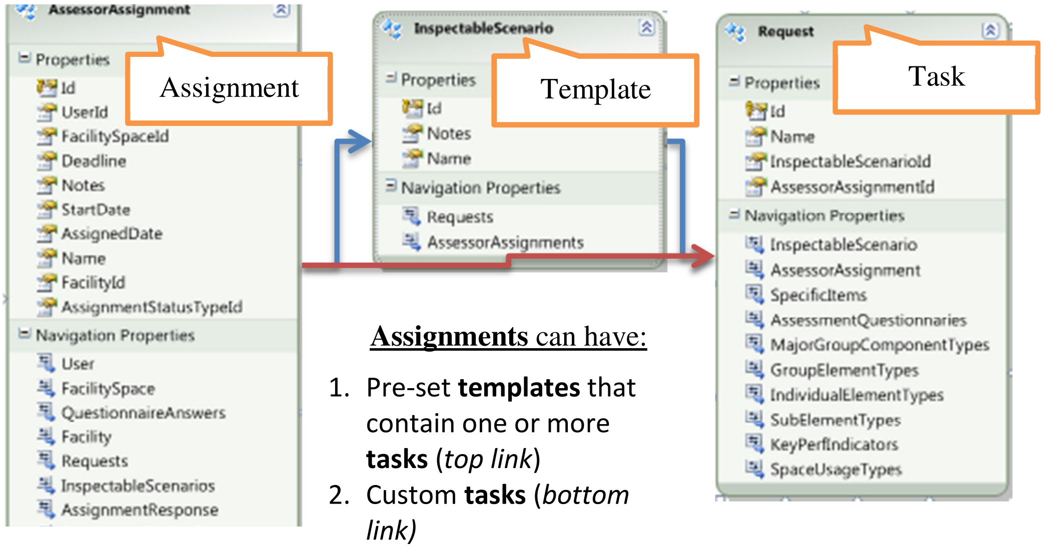


Figure 4.11 Assignment Structure in the Database

Figure 4.12 shows the user interface that allows administrators to create tasks by selecting components (left) and survey elements (right) that apply to those components.

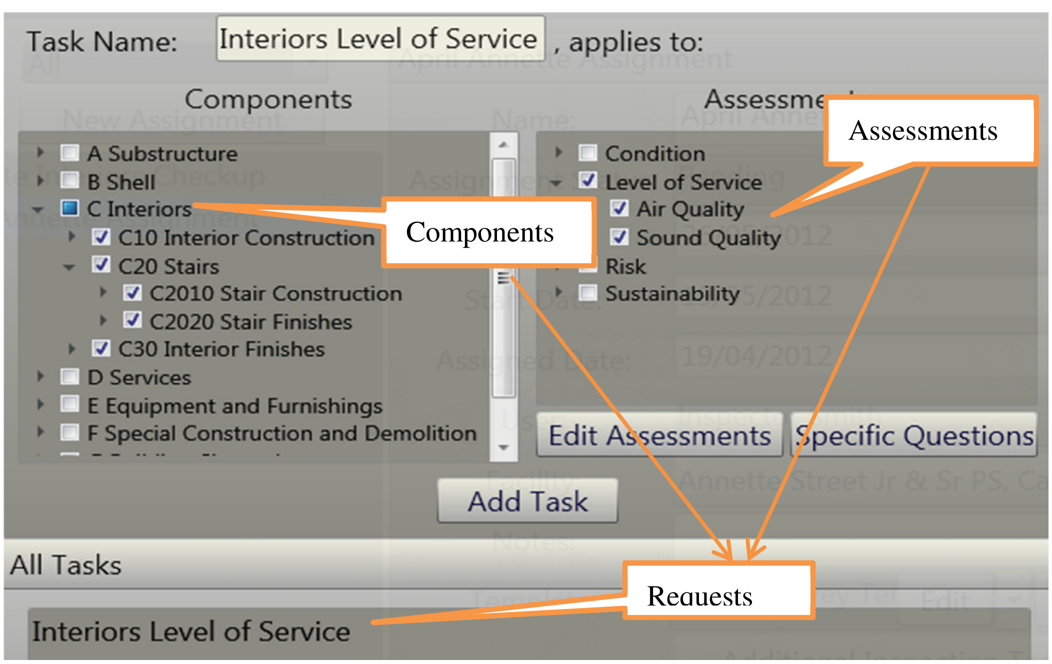


Figure 4.12 Adding a Request

In addition to standard surveys, administrators may choose to assign specific questions directly. This design (represented by the bottom link on Figure 4.13) allows adding/modifying survey elements without the need to hard-code them into database fields. The design flexibility allows the application to adapt to the challenges of changing survey structures discussed previously in Chapter 3.

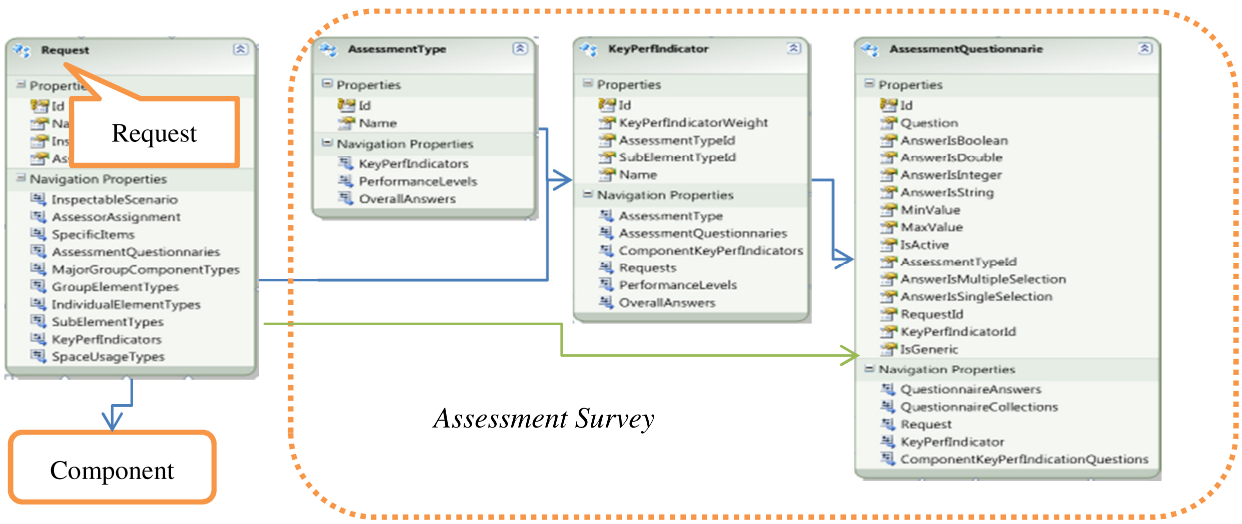


Figure 4.13 Requests

While flexibility was established as an essential factor , it is also important to have a structured survey, as clarified in Chapter 2. Therefore, the system is designed to have a standard three level hierarchy (Figure 4.14) that is based on the findings of the literature review from Chapter 2:

1. Level 1: Assessment Type
2. Level 2: Key Performance Indicator
3. Level 3: Specific Questions

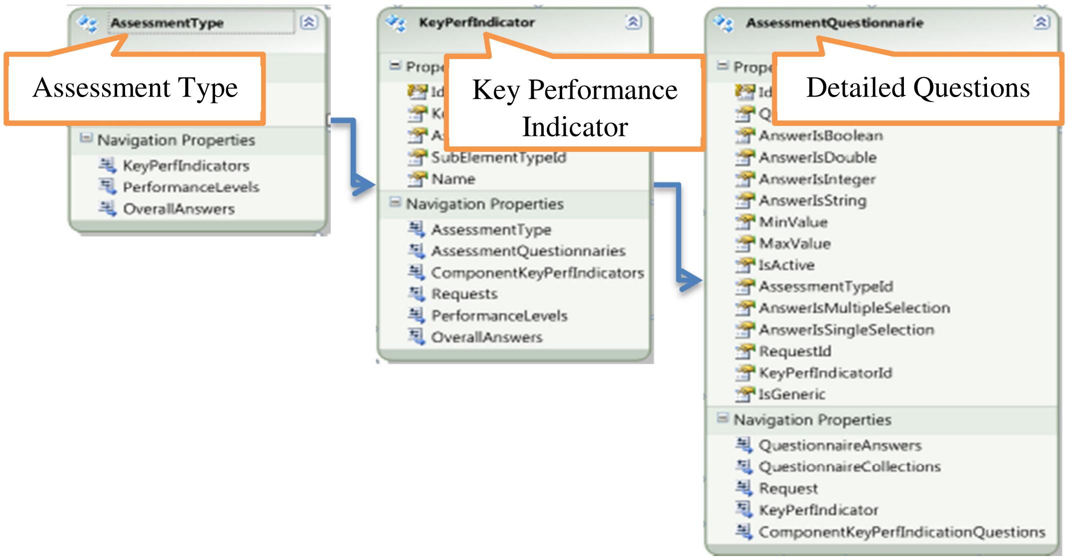


Figure 4.14 Hierarchical Assessment (Survey) Structure

The assessment interface (Figure 4.15) is designed to intuitively resemble the database hierarchy; selecting an assessment type displays an editable list of key performance indicators, while selecting a key performance indicator displays an editable list of questions. The weighted assessment design greatly improves the maintenance process by providing powerful prioritization support data based on assessment types, key performance indicators and questions. Each level in the hierarchy may be assigned a “weight” value, which determines its impact on the overall assessment, similar to component weights discussed in subsection 4.3.1. Detailed questions allow administrators to include numeric, true/false and descriptive survey details.

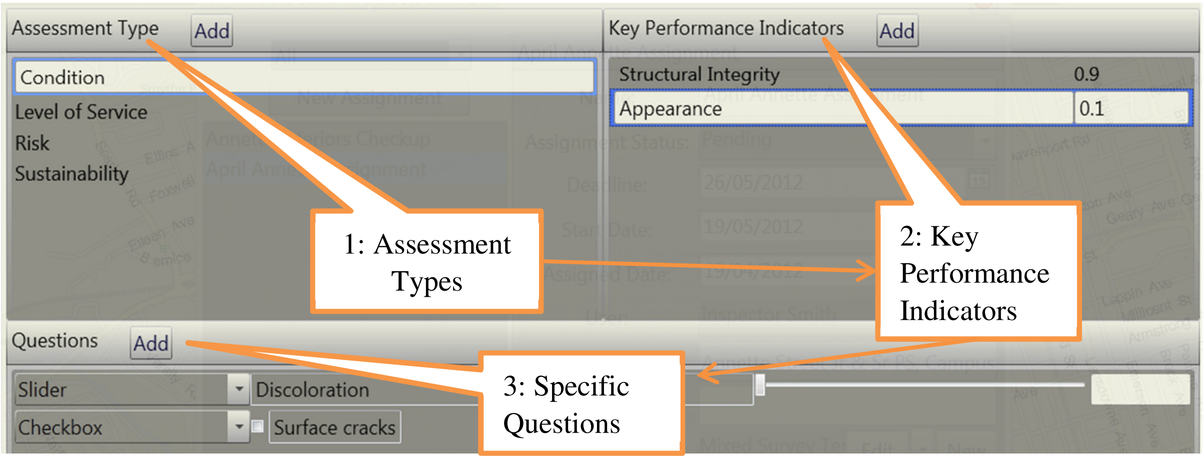


Figure 4.15 Assessment Design Window

The application interface for adding assignments also displays adding basic assignment information such as date and general notes, assigning an inspector and choosing a preset template. Custom tasks may be added by selecting "Additional Inspection Tasks", as seen in Figure 4.16.

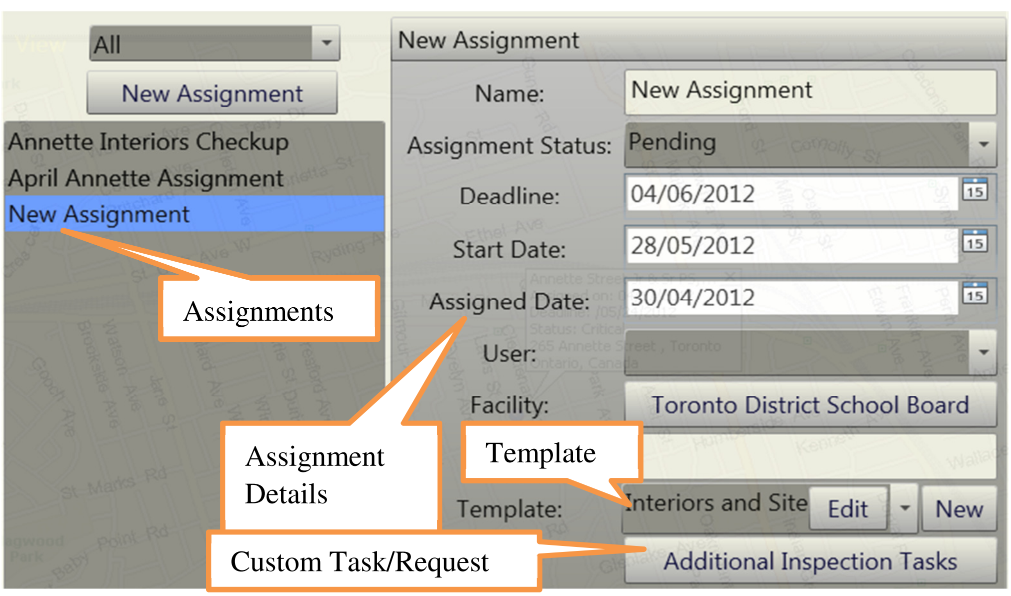


Figure 4.16 Assignments

Finally, reporting is accomplished after inspectors receive assignments, enter inspection data and synchronize the results. Database table fields are used to generate reports based on date, location, inspector, component, etc. Reporting is especially useful due to the wide range of information types that are integrated in the system. For instance, using the facility 3D model to highlight defects visually can assist in identifying localized defects or failure trends. Reports that are automatically associated with inspection pictures and are available for referencing during future inspections also greatly increase inspection accuracy and consistency. Generated reports using those tools have to potential to cut maintenance costs and improve renewal and repair decision support. Reporting interface has not been fully developed in this prototype due to time constraints. Future development should produce reports using integrated GIS, 3D and imaging tools that are included with the current prototype.

Figure 4.17 summarizes the overall database design for creating structured, flexible and reusable assignments: the top part summarizes the assignment creation structure using individual tasks/requests. The bottom part shows the flexible assignment design by linking a component from the bottom left side and an assessment structure from the bottom right side to a task entity.

The following section explains the role of the database in storing and communicating data between administrators and inspectors as well as some of the database design attributes in this system prototype.

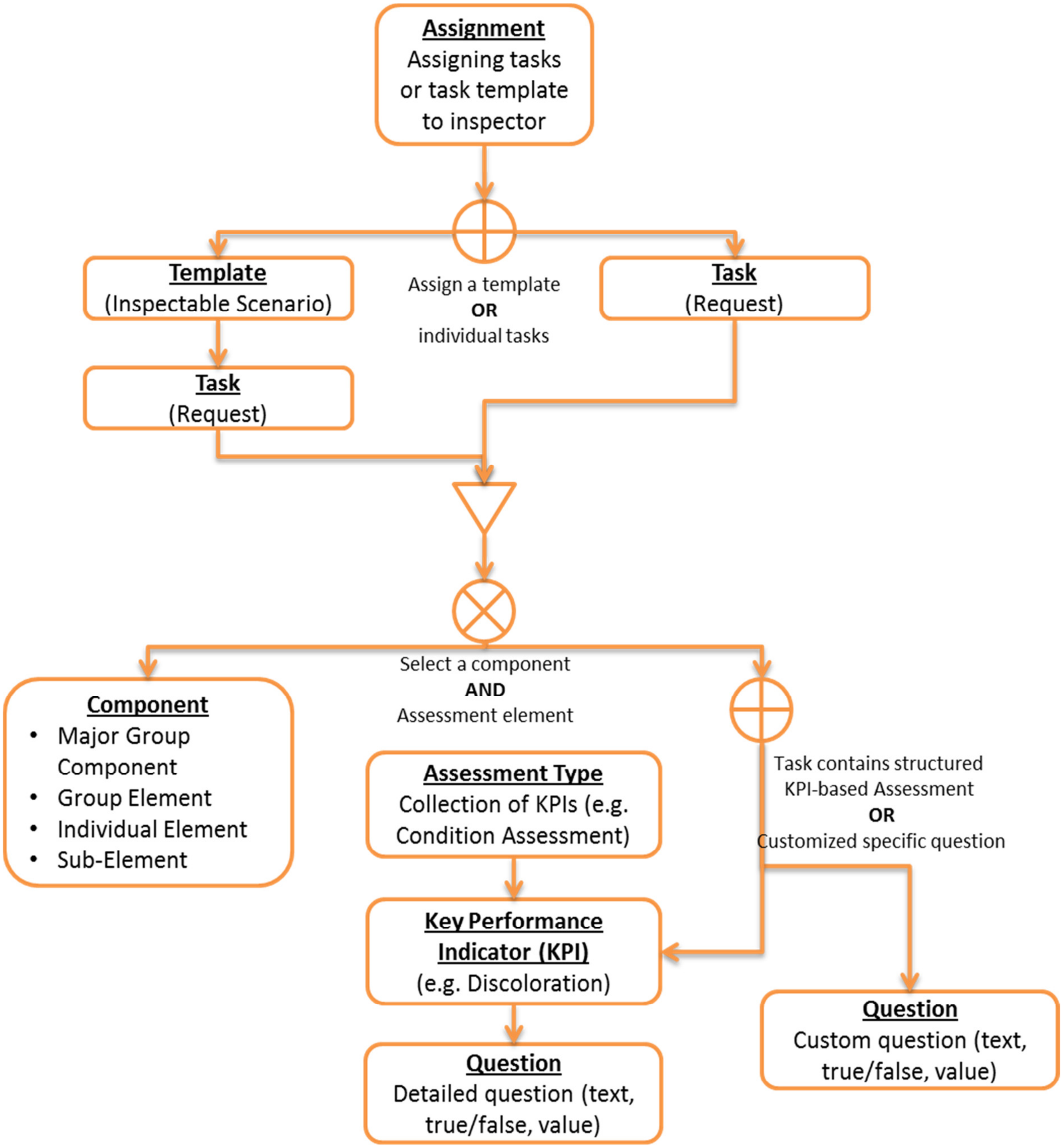


Figure 4.17 Overall Assignment Process Design

The link between administrative work and on-site inspections is established through online data synchronization. For instance, assignments created by administrators are delivered and received automatically as they are created. Data is synchronized back as inspectors perform their assigned inspections, as illustrated in Figure 4.18. The three main components of the application are discussed in the following subsections.

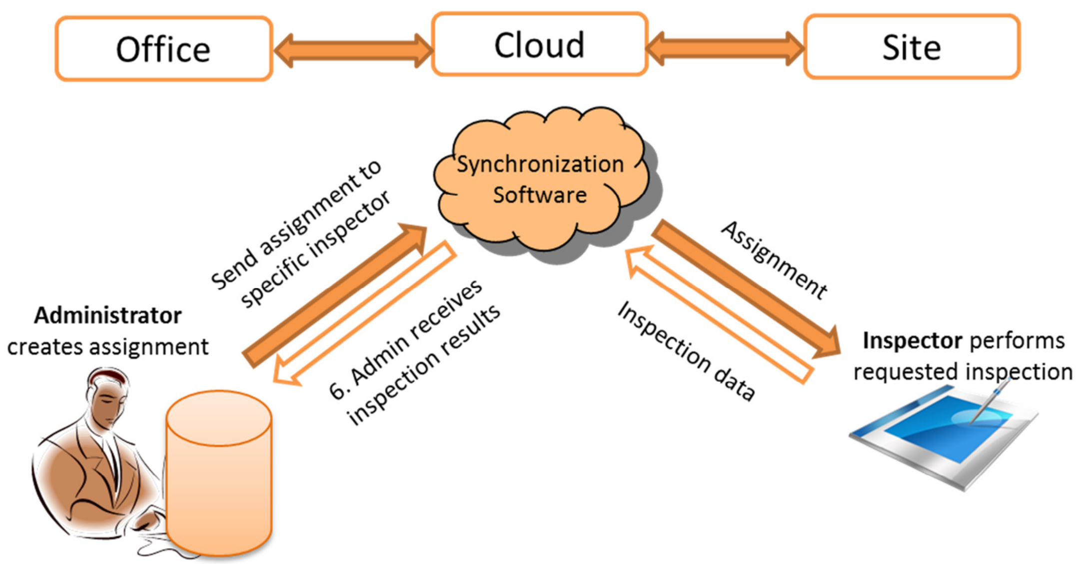


Figure 4.18 Assignment Creation and Inspection

4.4 Database Structure

The central database of the infrastructure management system has been created as a relational MS SQL database, which has one of the most diverse and practical database structures available. The design of the database tables and relations was done using the Microsoft's Entity Framework. The database is composed of a total of 72 tables, 53 entities, 120 associations and 139 constraints, with the most interconnected table containing 15 links to other tables. Table 4.2 summarizes the database structure. Because of the large size of the database, a single figure cannot display it all adequately. Thus, parts of the database will be shown in proximity to the description of the main functions in the inspection management system.

Table 4.2 Database Table Composition

Property	Count
Tables	72
Entities	53
Associations	120
Constraints	139
Maximum Links to 1 Table	15

4.5 Inspector Functions

Once logged in as an inspector, the system synchronizes user-specific assignments with the central database through the internet. The inspector is then presented with a map that only displays relevant facilities and assignments (

Figure 4.19). The visual GIS presentation provides the inspector with a tool that complies with Ministry recommendations mentioned in Chapter 3 to minimize travel time and costs between inspections. After choosing an assignment, the inspector can proceed to perform the following two functions as discussed previously in section 4.2 (Figure 4.1):

Figure 4.19 Facilities Containing Assignment Display - Inspector View

4.5.1 Navigating the Building:

When an inspector selects an assignment, a 3D model of the facility that was entered by an administrator is displayed (Figure 4.20). The inspector is able to navigate through the facility's 3D model by building, floor or floor-space using the "Spaces" control, and the tablet touch screen or other input devices (such as a computer mouse) to rotate the 3D model, zoom or switch to 2D viewing mode. The inspector can make observations directly on the 3D model to increase inspection efficiency. This is particularly useful for taking notes about the facility while discussing facility and component conditions with in-house personnel, as discussed in Chapter 2.

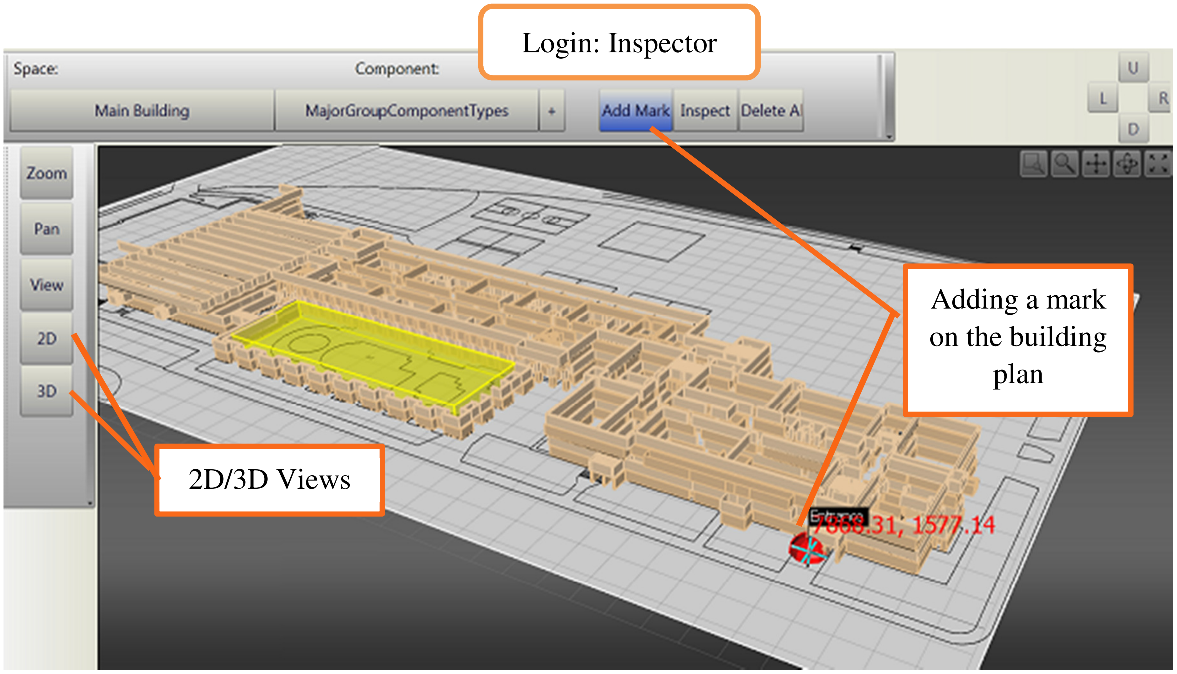


Figure 4.20 Inspector View of 3D Facility Model

The inspector then selects one of the components listed in the “Component” control in order to enter inspection data for it. Finally, the inspector marks defects horizontally or vertically on the building model by drawing a rectangle as shown in Figure 4.21 and Figure 4.22. The ability to mark defects horizontally or vertically is especially useful for accurate identification of defects, which leads to better repair and maintenance actions. Once a component is selected, the assessment window opens and displays the requested assignment details for that component. A picture module, component history and visual guidance system are also displayed to assist the inspector with component assessment.

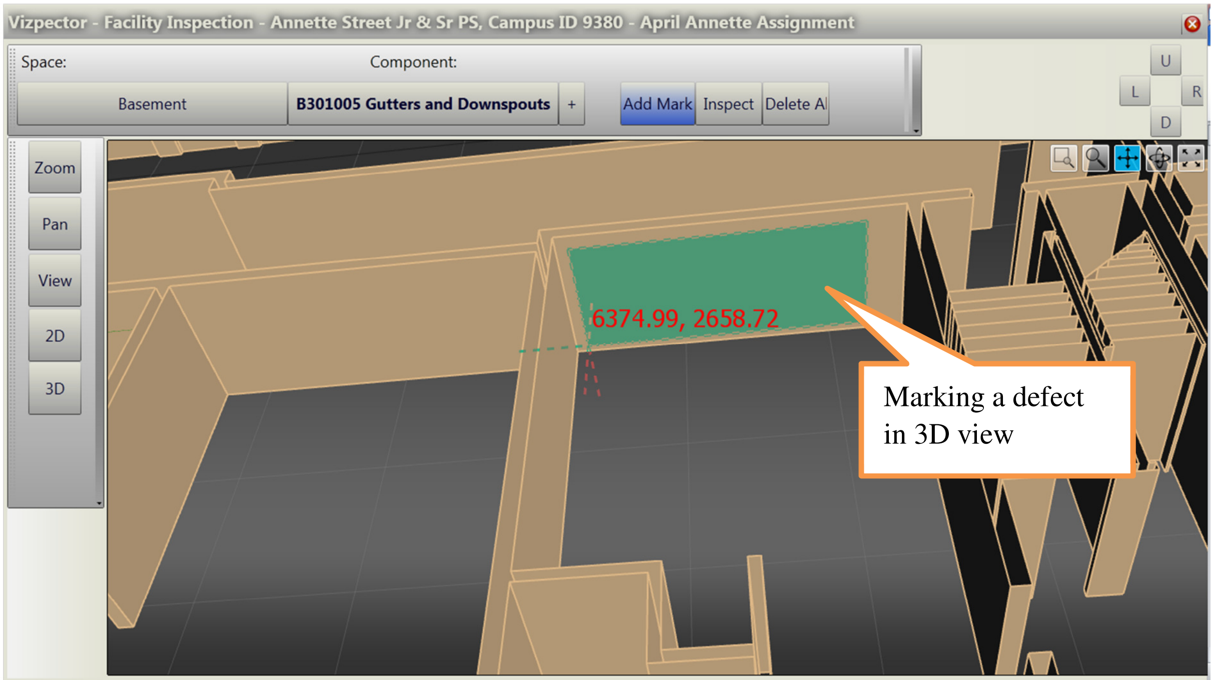


Figure 4.21 Marking a Vertical Defect on the 3D Plan

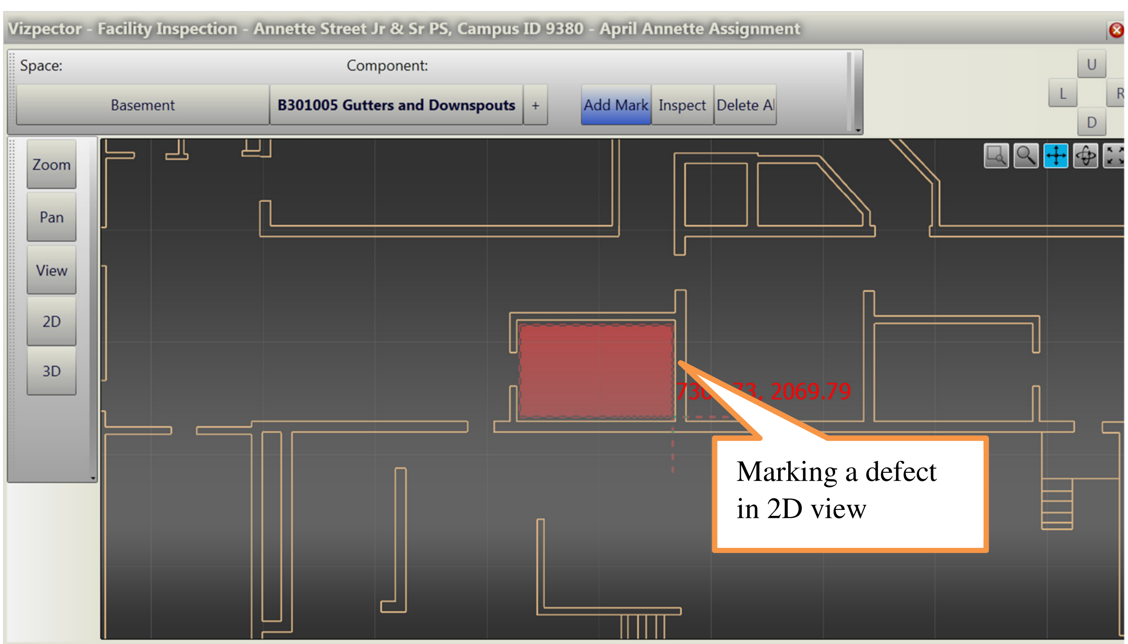


Figure 4.22 2D Defect Marking

4.5.2 Responding to Assignments:

The main assessment window for the selected component and location of the defect displays all assessments, KPIs, questionnaires and specific requests that are assigned by the administrator for that particular component (Figure 4.23). While inspecting this component, the system has been designed to allow the inspector to perform five main functions:

1. Perform assessment: The inspector is presented with a stacked list of the following task elements:
   a. Assessment types, which are expandable to display KPIs. The inspector can assign a value to each assessment type, which affects the overall condition of the component being inspected based on its importance. Additionally, the inspector may choose to answer individual KPIs.
   b. KPIs: answering KPIs affects their hierarchical assessment type according to KPI weights. If any specific questions are included in the KPI hierarchy, the inspector can expand the selected KPI and provide answers as well.
   c. Specific Questions: Specific questions can be text, true/false, or value based. Value based specific questions can also have weights assigned to them that help the inspector determine the value of their KPI. Additional Questions are displayed the aggregated list of

assessment types directly if they do not follow the assessment structure (e.g. General Description)

2. Take pictures: The inspector can take photos and record short videos of the component under inspection, as seen in Figure 4.24.The inspector can also include notes with each visual element that serves as a permanent reference that is associated with the component.
3. View component history: The inspector can view previous inspection data. Having previous component inspection information readily available is a great asset to the inspector as it provides information such as past replacements and deterioration trends. This insight can help the inspector make better recommendations to reduce future costs and better perform preventative maintenance.
4. Consult the visual guide: The inspector accesses sample pictures of components of the same type as the one being inspected. Each picture is accompanied with a descriptive condition guide as shown in Figure 4.25. Granting inspectors access to the same set of sample pictures and condition descriptions allows them to make similar assessment decisions and recommendations, which greatly reduces inspection subjectivity and improves fund allocation, reducing overall costs.
5. View/Modify details: The inspector views and edits component data fields, such as age and serial number. Verifying and updating these details make assessments more reliable by keeping track of an updated asset inventory.

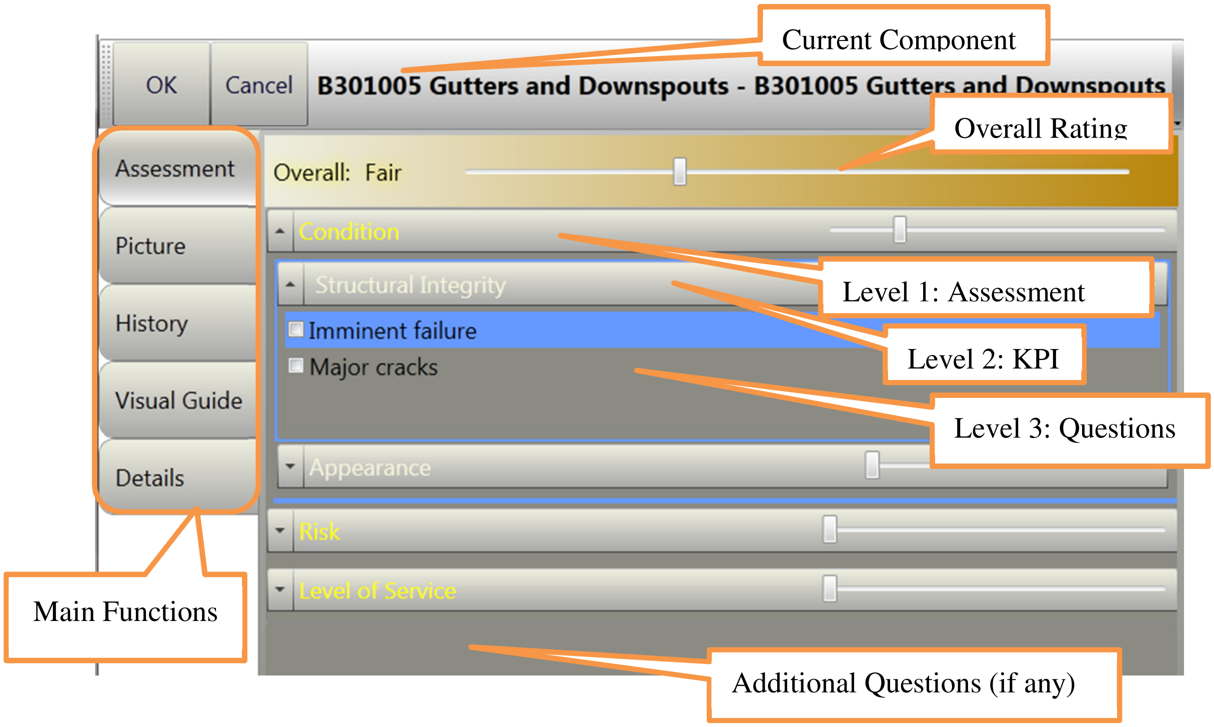


Figure 4.23 Inspector Assessment

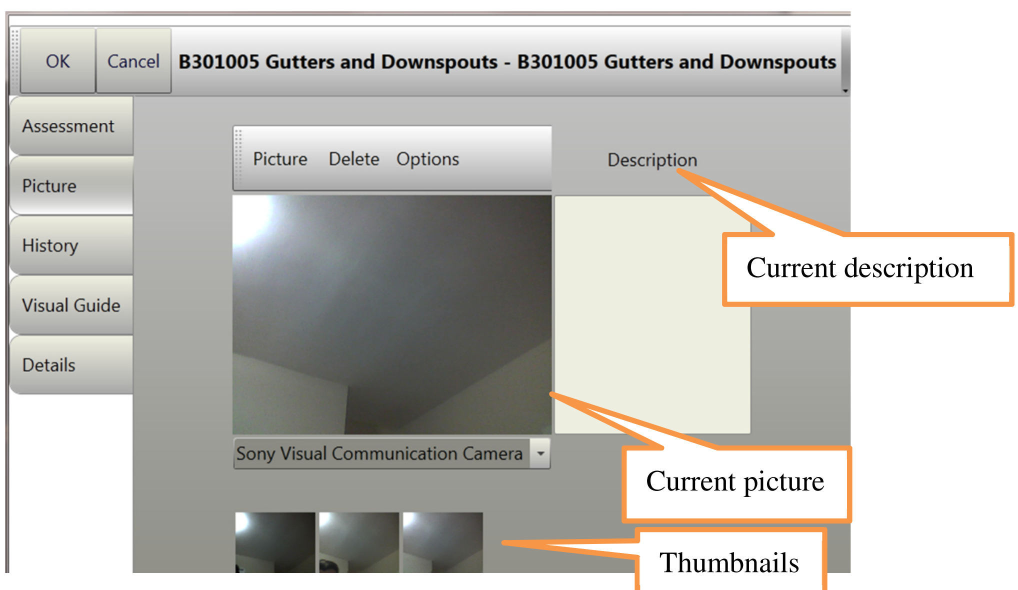


Figure 4.24 Picture Module

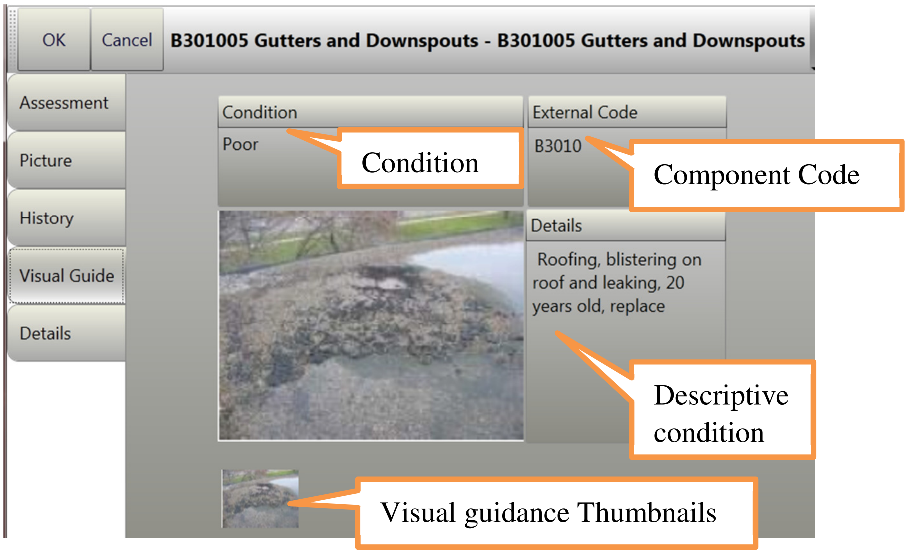


Figure 4.25 Visual Guidance

4.6 Prototype Example

In order to demonstrate the effectiveness of the inspection management system, a new sample assessment is created and assigned to an inspector after adding a new sample school. The example demonstrates adding a new building, creating an assessment, compiling an inspection scenario and assigning the scenario to an inspector. It also shows the inspector responding to the assessment by responding to the sample assignment.

4.6.1 Adding a New Building:

A sample facility is added by an administrator in order to assign an inspection. Adding a facility was done through the following five steps:

1. Entering Facility Information (Figure 4.26): An administrator filled in basic facility information, such as, name, organization and address. The system automatically verified the address and displayed the new facility on the map (as previously shown in Figure 4.3), The sample school name was Annette Street Jr., and was located at 265 Annette St., in Toronto, ON.

2. Defining Facility Site Plan: The administrator began entering facility model information by importing the site plan CAD file. After specifying the file plan for Annette St. Jr., the administrator unchecked unnecessary CAD layers including the 12PAPER and 17BORDER layers seen previously in Figure 4.6.

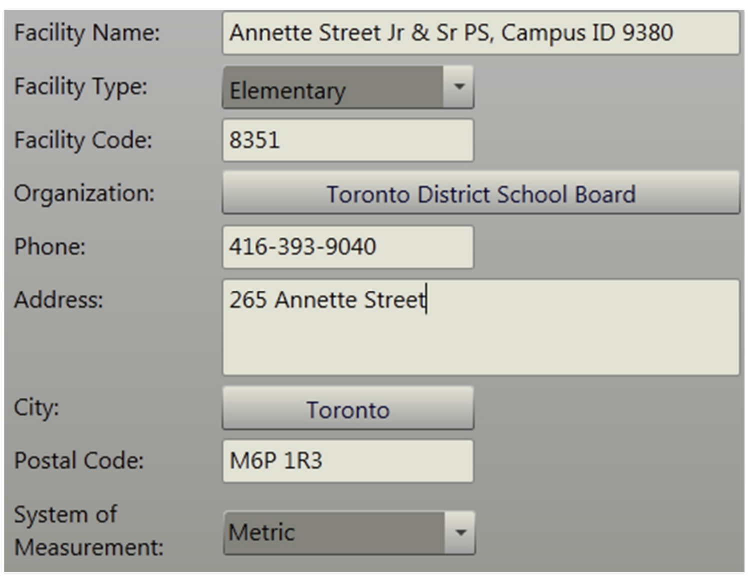


Figure 4.26 Step 1: Facility Information

3. Adding Facility Spaces: Annette St. Jr. had a single “main building”, which was added by entering its name, construction date, value, and by marking it on the site plan as was shown previously in Figure 4.7.
4. Defining Floors: A basement, first and second floors were added to the “main building” by uploading their individual floor plans. Unnecessary layers were then filtered out using the same method of unchecking extra layers that was used in Step 1. Finally, the floor plan was aligned to the site plan as illustrated previously in Figure 4.8.
5. Defining Floor-Spaces: A two-floor “Gymnasium” was created on the basement floor, which reached up in height to the second floor. The space was added by drawing a rectangle horizontally on the basement floor and setting the floor height value to 2.

The entire building model was created in approximately five minutes. The resulting 3D model was generated immediately after adding each floor, resulting in the overall 3D facility model shown in Figure 4.27.

4.6.2 Creating a New Assessment:

The next step was to design an assessment in order to assign it to an inspector. A “Condition” assessment type (Figure 4.28) was created containing a “Structural Integrity” and “Appearance” KPIs (Figure 4.29) Assigning the “Structural Integrity” KPI a weight of 0.9 ensured that it would impact the “Condition” assessment more than the “Appearance” KPI, which had a weight of only 0.1.

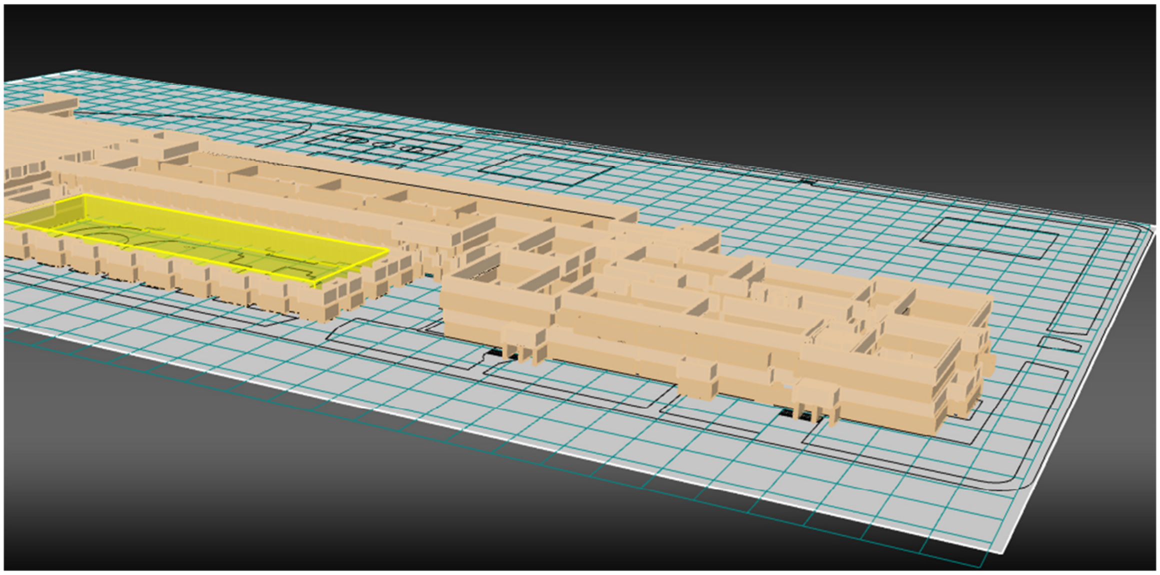


Figure 4.27 Example of the 3D Building for Annette Street Jr. School

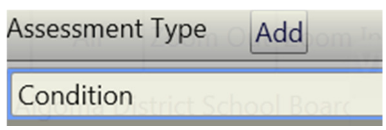


Figure 4.28 Adding a Condition Assessment

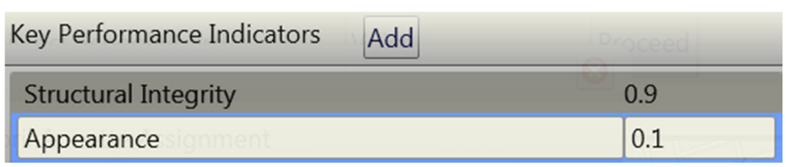


Figure 4.29 Adding Two KPIs

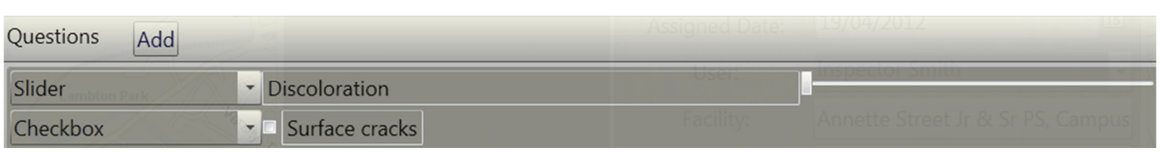


Figure 4.30 KPI Questions "Discoloration" and "Surface Cracks"

While the “Appearance” KPI was selected, two detailed Questions were added; “Discoloration” and “Surface Cracks”. While “Discoloration” was assigned a value-based slider to indicate the amount of color change, “Surface Cracks” was assigned a checkbox value that only checked for the presence of surface cracks that affect the “Appearance” of a component.

The entire assessment was designed in approximately one minute. Adding more complex assessments would have required more time, but would still be reasonable based on the current sample assignment.

4.6.3 Creating an Inspection Template

In order to use the “Condition” assessment in assignments, a reusable template was created. The sample template was created to perform a condition assessment on the “Foundations” and “Superstructure” components by selecting their corresponding checkboxes and adding the task to the inspection template. (Figure 4.31, Figure 4.32 and Figure 4.33).

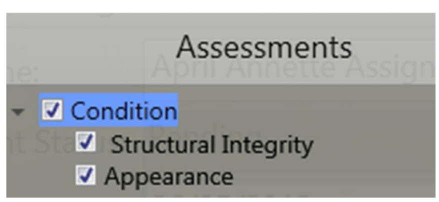


Figure 4.31 Selected Task Assessments

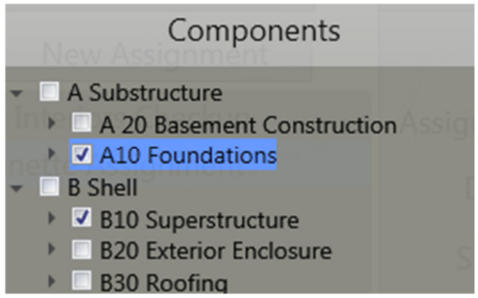


Figure 4.32 Task Components

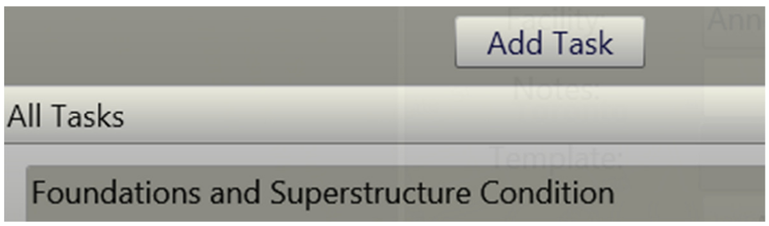


Figure 4.33 Template With a Single Task

4.6.4 Assigning Inspection

An inspector was given an assignment using the condition inspection template by specifying the date, facility, inspector and tasks. The assignment was named “Annette Condition Inspection” (Figure 4.34).

4.6.5 Receiving Inspection

As soon as an inspector signed in, he/she was greeted with a map that showed the location of assignments including the “Annette Condition Inspection” (Figure 4.35). Selecting the “Annette Condition Inspection” and proceeding took the inspector directly to the facility 3D inspection view.

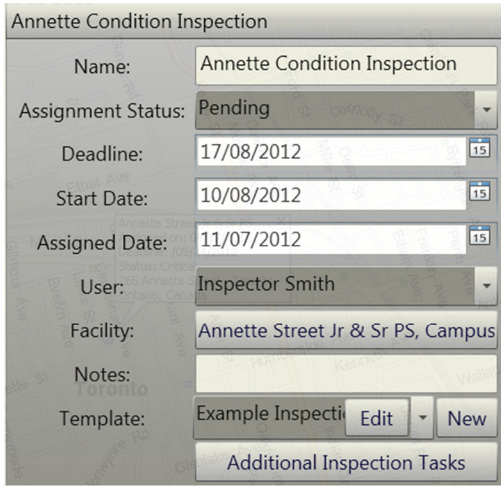


Figure 4.34 Assigning an Inspection

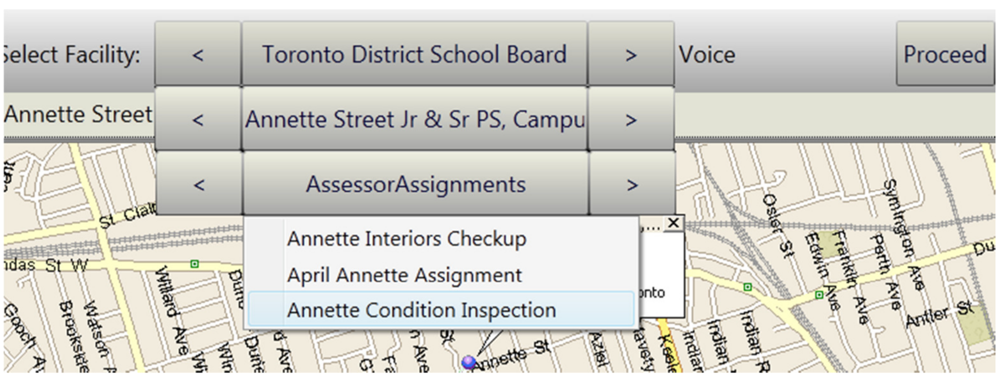


Figure 4.35 Inspector Assignment List

4.6.6 Performing Inspection

As the inspector entered the school, an observation about the entrance location was made. The observation could be observed in Figure 4.36.

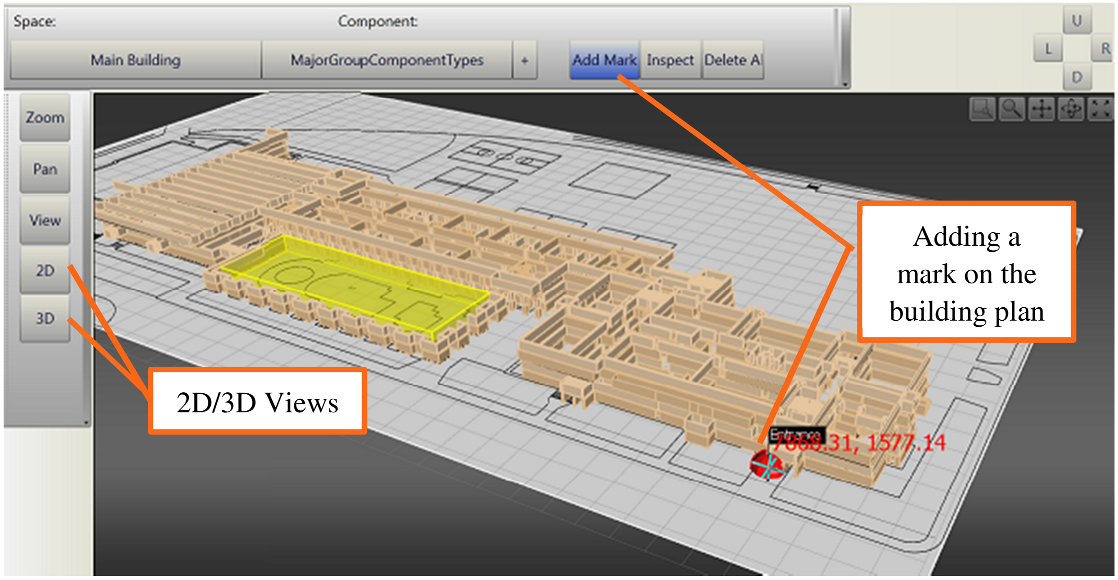


Figure 4.36 3D Facility Plan and 3D Marking

Once the inspector was ready to assess a component, the basement floor was selected using the Space hierarchical list control by navigating to the Main Building, then selecting the Basement floor as shown in Figure 4.37. The "Foundations" component was then selected from the Component list control as shown in Figure 4.38.

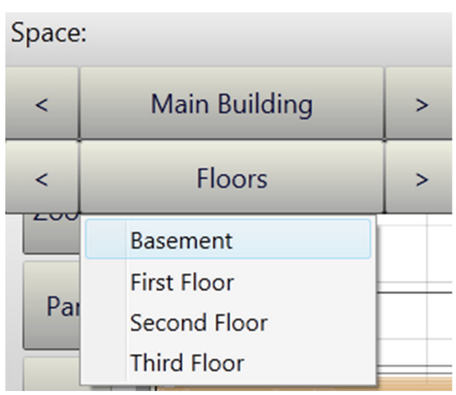


Figure 4.37 Hierarchical Floor Selection

Once the basement floor was selected, the 3D system automatically navigated to that floor and hid other floors to simplify the view for defect marking as shown in Figure 4.38.

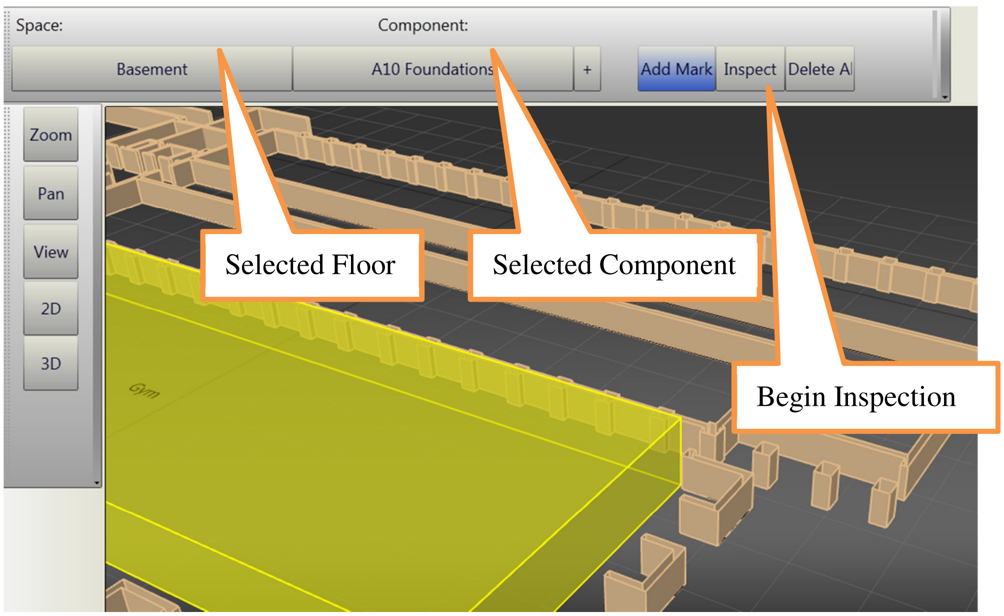


Figure 4.38 Selecting Floor and Component

To begin inspecting the selected component, the defect location was marked horizontally on the 2D floor plan on the 3D floor plan as shown previously in Figure 4.21.

The initial inspection window displayed the component that was being assessed and had several options for performing an assessment, taking pictures, reviewing component history, consulting the visual guide and modifying details, which could be seen previously in Figure 4.23.

The inspector began by taking pictures of the cracks in the Foundations component at that location (Figure 4.39). This would allow administrators at the office to look back and reevaluate the condition assessed by the on-site inspector for accuracy if necessary. Three pictures were taken and displayed as clickable thumbnails at the bottom. The inspector also noted “Water damage” and added it to the picture description, which was associated with that particular picture.

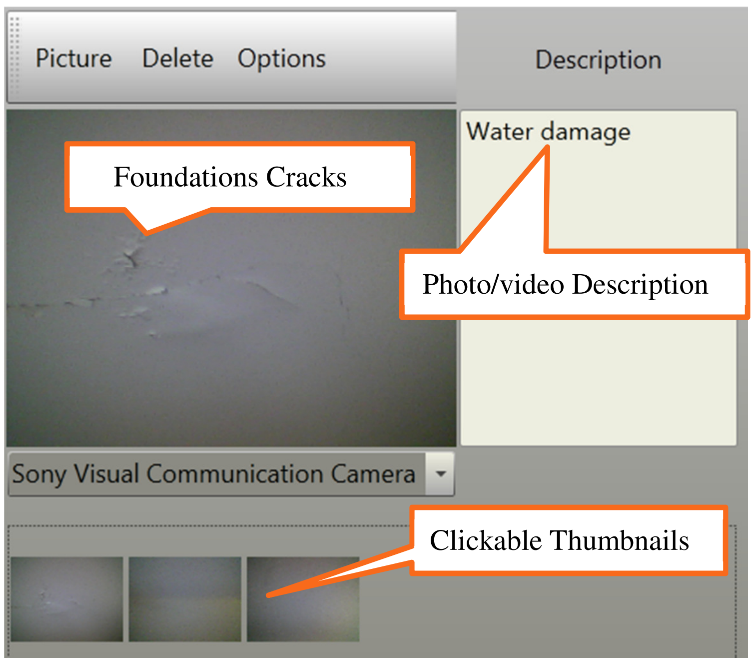


Figure 4.39 Picture Showing Foundation Cracks

After visually assessing the condition of the component, the inspector selects the Visual Guide option to compare it with sample photos of a similar component. The Visual Guide automatically displayed a reference A10 Foundations example of a component in “Fair” condition as shown in Figure 4.40. A list of clickable thumbnails at the bottom of the module would allow the inspector to access other examples had more been loaded into the system.

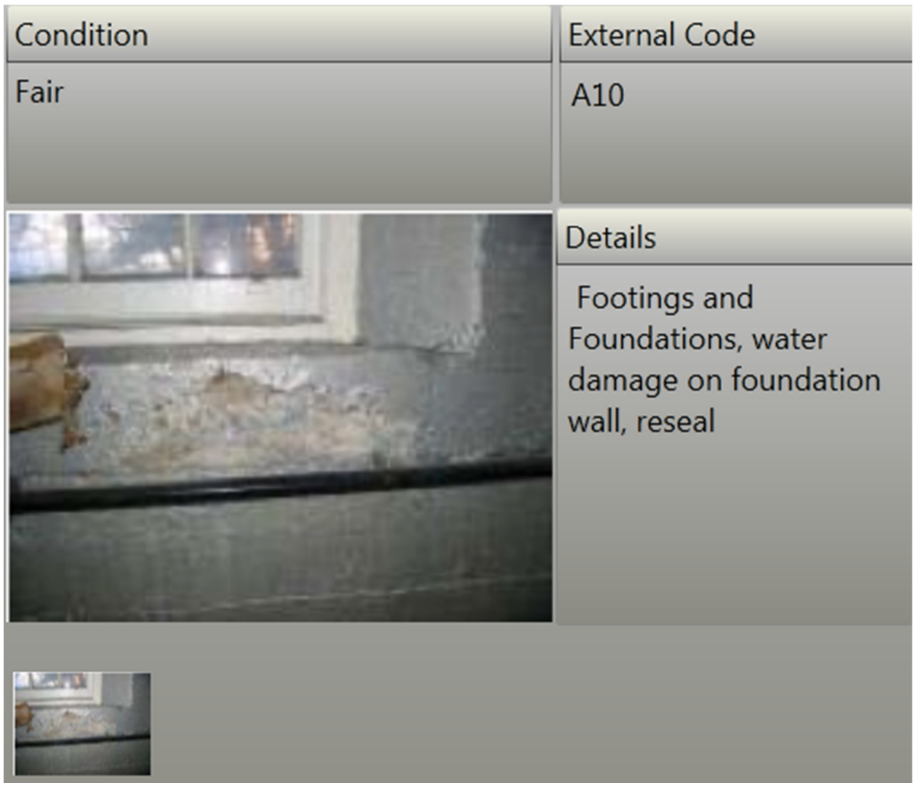


Figure 4.40 Visual Guidance for A10 Foundations

After referring to the Visual Guide system, the inspector was ready to assign a value to the overall condition of the Foundations component. Because it is in a similar condition of water damage to the example in the Visual Guide system, the inspector decided to assign a “Fair” condition to the component. The background color of the overall condition automatically changed from green to a yellowish color to visually reflect the degradation from “Excellent” and “Good” to “Fair” (Figure 4.41). The weighted values of the Key Performance Indicators “Structural Integrity” and

“Appearance” were modified by the inspector, which automatically calculated the “Condition” assessment type value. The overall component condition was also automatically calculated based on the assessment value. Modifying the calculated results manually was possible, but the inspector decided to keep the calculated values rather than manually modify them because they agreed with his judgment and because they were consistent with the Visual Guide sample. Finally, the inspector assigned a value to the “Discoloration” and checked “Surface” cracks under then “Appearance” KPI.

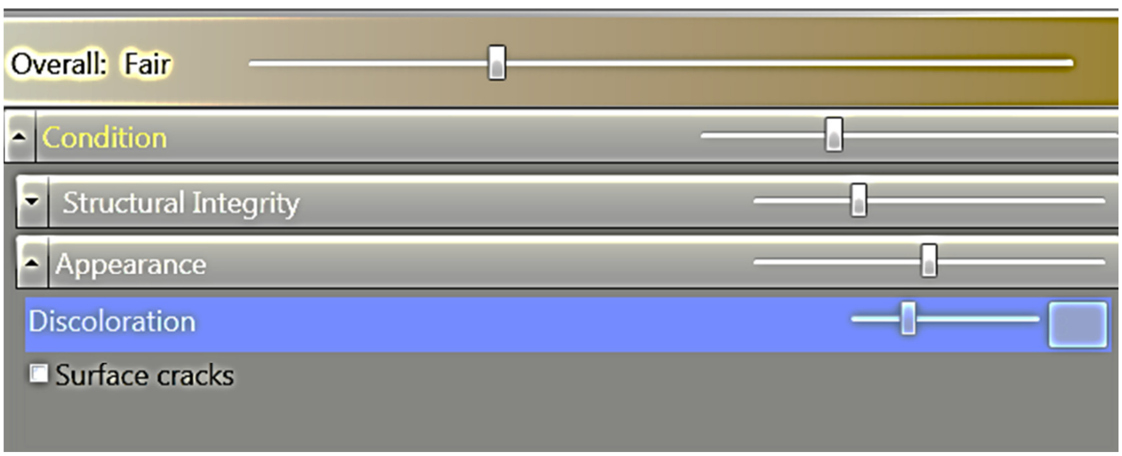


Figure 4.41 Answering Inspection Questions

The inspector went through the facility, repeating the inspection process for all of the components of the “Foundations” and “Superstructure” types that he was able to locate in the building. He continuously referenced the 3D facility model, marking defects, and consulted the Visual Guide module to make consistent assessments.

4.7 Feedback on the Developed System

The system was reviewed by a number of well-known development firms including the Toronto District School Board, Riva Modeling and Pattern Discovery Technologies Inc. Through several group demonstrations, the benefits of the 3D features were greatly appreciated, along with the solid database design of the system. Among the features that were examined thoroughly was the time it took to create 3D models for new buildings. The system's average of five minutes was determined to be an excellent time for creating new facility plans. This was commented upon as an important factor to quickly import legacy data, which can be extremely large in case of multiple buildings, to the proposed system. The flexible assessment creation process was also assessed to be creative and practical for large organizations. The integrated camera and Visual Guide tools were highly valued as tools that improve consistency, speed, and the all-on-site performance of the system.

4.8 Conclusions

The integration of a well-structured asset inspection system with the aid of technological advances allows for a solid inspection management system that addresses the issues of unstructured inspections, lack of visual referencing, inspector subjectivity and lack of adaptability. It also gives flexibility in assessing various buildings and components and saves large amounts of resources that are being spent on current inspection methods.

Chapter 5
Conclusions and Future Research

5.1 Summary and Conclusions

Infrastructure assets have a significant effect on the quality of life and the overall performance of nations. North American infrastructure has been deteriorating and costing billions of dollars due to the failure of the maintenance process. Inspection is usually the first step in maintenance management; however, poor asset inspection management is one main reason for asset failure and the related costs. Lack of funding requires accurate assessments and justifications for prioritizing asset maintenance and allocating funds. The main objective of this research is to guide the asset inspection management large organizations by detailing an asset inspection management system that makes use of current technologies to fulfill the requirements of proper asset inspection by providing accurate, consistent and comprehensive condition estimates for building infrastructure.

The system mainly targets the following four challenges that face assessment systems: (1) the unstructured nature of inspection management, (2) the lack of visual reference during inspections, (3) the high subjectivity in the inspection management, and (4) the lack of adaptability to changing inspection types and assessment types.

The proposed system uses GIS location referencing, 3D technology, flexible assessments, picture and video integration, hierarchical data organization and visual referencing to improve the overall assessment process.

The system design is based on a previous study of the Toronto District School Board requirements that was performed by Shipra Singh (Ahluwalia 2008) and a detailed analysis of the requirements set out in a recent $20M bid by the Ministry of Education in Ontario (MERX 2011).

The resultant system included administrative and inspector functions. Administrative functions outlined facility data entry, including the definition of GIS coordinates, entering floor plans and creating a 3D facility model using a simplified process as well as dynamically designing reusable, flexible assessments and a synchronization based communication method. It also outlines a database design that makes reporting an intuitive and powerful tool. The inspector side is intended for a handheld device that displays a list of assignments by location and that is personalized for each inspector. It allows them to access 3D facility plans and survey questionnaires, using a simple checklist-like design, in addition to providing them with a visual guidance system and integrated photo/video capturing tools.

5.2 Research Contributions

The proposed system makes the following contributions:

- *Better clarification of current inspection challenges*: This study has reviewed data from previous research and existing literature to pinpoint dysfunctional asset maintenance processes by singling out the assessment process as the first contributor to this failure. Furthermore, it highlights challenges within the inspection process that contribute to wasted resources and the continuing deterioration in infrastructure asset conditions.

- *Creating a structured approach to asset inspection management*: The hierarchical design of the assessment system using assessments, key performance indicators and questionnaires, the Uniformat II component system, location and 3D referencing as well as component-linked picture and video modules make the inspection process highly organized and efficient.
- Establishing a prioritization system: The weighted approach to assessment and components enables organizations to easily prioritize components and simplifies and improves renewal, repair and rehabilitation decisions at strategic and tactical levels.
- Reducing subjectivity: The inclusion of a visual referencing system allows inspectors to perform consistent inspections by having descriptive text references as well as picture available for reference during inspections. These resources are associated with each component that is inspected, saving the inspector additional effort or extra training.
- *Visual referencing*: Having 3D facility plans available for referencing increases inspection effectiveness and provides a powerful tool for asset maintenance management decisions. The low resource cost of 3D plan creation also makes it

an attractive choice because it saves resources and avoids the need for extensive initial setup resources.

- *Adaptable inspection system*: Reusable scenarios based on requests, component-specific assessments and assignment-specific questions and requests, makes the system highly versatile, flexible and cost effective.
- *Development of a prototype inspection system*: The prototype that is introduced in this research provides a structured, adaptable system that contains 3D visual referencing and reduces subjectivity while being user friendly and cost effective.
- *Effective communication:* The automatic synchronization of data allows administrators to assign any number of requests quickly and easily as well as to receive data through synchronization. Synchronization saves many hours that would otherwise be wasted on manual data transfer and allows for quick and powerful reporting.
- *Expandable prototype*: The system was developed with educational facilities in mind. However, minor modifications, such as changing the organizational hierarchy, allow the system to be used for any number of large owner organizations.

5.3 Future Research

The following are some of the areas that may improve the effectiveness of the system upon further development and exploration:

- Optimizing prioritization: The current system's weighted component and assessment approach gives a powerful component-repair prioritization tool. Further development may include other measures for prioritization that are not based on the importance of components and assessments alone, but also on the cost effectiveness of renewal and maintenance projects. For instance, the system may allow administrators to enter individual component deterioration models to predict future failures and perform cost-effective preventative maintenance.
- Automatic location referencing: An area that may be explored is the inclusion of a type of indoor positioning system that automatically pinpoints inspector location and displays it on the 3D model. Development may include automatic position updates for major components and monitoring systems that prompt inspection work.
- *Automatic assignment correlation*: While the current system allows for a very flexible assignment creation process, it does not automatically cover assignment categorization. Further development may allow the system to assign and/or recommend certain assessments based on criteria such as school age, location, school board or last inspected information.

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Appendix A
Ministry of Education Summary of In-Scope Educational Facility

DSB No.	DSB Name	Facilities for Full Condition Assessment (FCA)									
		Administrative Buildings		Continuing Education Buildings		School Buildings				Total Facilities for FCA	
		Number	Area (sq.m.)	Number	Area (sq.m.)	Number	Area, Permanent Facility (sq.m.)	Area, Relocatable Classroom Module (sq.m)	Total Area (Permanent Facility + RCMs)	Number	Area (sq.m.)
Provincial Total		**71**	**461,346.08**	**77**	**464,159.02**	**4,675**	**24,658,956.44**	**740,900.46**	**25,399,856.90**	**4,823**	**26,325,362.00**
GTA Region (1.00)		**12**	**89,016.30**	**31**	**174,568.95**	**1811**	**11,296,880.75**	**314,958.87**	**11,611,839.62**	**1854**	**11,875,424.87**
12	Toronto District School Board	1	9,632.30	8	101,416.75	564	4,052,749.10	40,250.00	4,092,999.10	573	4,204,048.15
13	Durham District School Board	1	12,038.00	0	0.00	125	703,179.50	23,316.17	726,495.67	126	738,533.67
16	York Region DSB	1	4,070.00	1	1,393.50	178	1,231,382.60	24,324.50	1,255,707.10	180	1,261,170.60
19	Peel DSB	1	14,138.00	0	0.00	231	1,495,924.40	62,699.00	1,558,623.40	232	1,572,761.40
20	Halton DSB	1	4,910.00	1	2,372.00	93	543,699.50	17,780.00	561,479.50	95	568,761.50
40	Toronto Catholic DSB	1	13,470.00	17	60,772.70	205	1,022,277.00	34,020.00	1,056,297.00	223	1,130,539.70
42	York Catholic DSB	1	13,580.00	1	1,814.00	98	579,355.35	22,515.20	601,870.55	100	617,264.55
43	Dufferin-Peel Catholic DSB	1	8,854.00	2	5,551.00	139	850,278.00	52,982.00	903,260.00	142	917,665.00
45	Durham Catholic DSB	1	2,116.00	1	1,249.00	45	233,332.80	17,288.00	250,620.80	47	253,985.80
46	Halton Catholic DSB	1	3,873.00	0	0	46	271,680.60	12,212.00	283,892.60	47	287,765.60
58	CSD du Centre Sud-Ouest	1	1,188.00	0	0	39	139,328.50	1,412.00	140,740.50	40	141,928.50
64	CSD catholique Centre-Sud	1	1,147.00	0	0	48	173,693.40	6,160.00	179,853.40	49	181,000.40
Central Region (2.00)		**15**	**180,107.60**	**21**	**197,096**	**1055**	**5,005,999.30**	**196,470.25**	**5,202,469.55**	**1091**	**5,579,673.05**
14	Kawartha Pine Ridge DSB	1	7,918.00	0	0	91	405,220.25	8,347.95	413,568.20	92	421,486.20
15	Trillium Lakelands DSB	1	1,842.00	0	0	54	218,589.50	5,560.00	224,149.50	55	225,991.50
17	Simcoe County DSB	1	8,023.80	0	0	111	536,118.15	20,779.00	556,897.15	112	564,920.95
18	Upper Grand DSB	1	4,022.00	2	2,764.00	69	338,344.50	14,327.30	352,671.80	72	359,457.80
21	Hamilton-Wentworth DSB	1	97,000.00	5	159,661.00	114	640,791.80	21,880.00	662,671.80	120	919,332.80
22	DSB of Niagara	1	6,977.92	1	2,133.90	117	551,173.70	2,620.00	553,793.70	119	562,905.52
23	Grand Erie DSB	1	15,940.00	0	0	77	344,246.70	7,875.00	352,121.70	78	368,061.70
24	Waterloo Region DSB	1	12,715.00	0	0	114	611,259.70	38,583.68	649,843.38	115	662,558.38
41	Peterborough V N C Catholic DSB	1	2,589.67	0	0	37	161,375.80	10,983.30	172,359.10	38	174,948.77
44	Simcoe Muskoka Catholic DSB	1	1,919.00	0	0	53	228,309.20	11,830.00	240,139.20	54	242,058.20
47	Hamilton-Wentworth Catholic DSB	1	6,500.00	4	8,557.00	55	286,388.00	13,881.00	300,269.00	60	315,326.00
48	Wellington Catholic DSB	1	1,286.77	0	0	19	87,800.70	5,550.63	93,351.33	20	94,638.10
49	Waterloo Catholic DSB	1	8,155.00	5	18,145.00	51	222,630.20	12,786.00	235,416.20	57	261,716.20
50	Niagara Catholic DSB	1	3,995.00	4	5,835.00	61	270,318.90	13,803.80	284,122.70	66	293,952.70
51	Brant Haldimand Norfolk Catholic DSB	1	1,223.44	0	0	32	103,432.20	7,662.59	111,094.79	33	112,318.23

DSB No.	DSB Name	Administrative Buildings		Continuing Education Buildings		School Buildings				Total Facilities for FCA	
		Number	Area (sq.m.)	Number	Area (sq.m.)	Number	Area, Permanent Facility (sq.m.)	Area, Relocatable Classroom Module (sq.m)	Total Area (Permanent Facility + RCMs)	Number	Area (sq.m.)
South West Region (3.0)		**10**	**63,904.26**	**11**	**47,420.77**	**601**	**2,888,462.83**	**63,914.47**	**2,952,377.30**	**622**	**3,063,702.33**
7	Bluewater DSB	0	0.00	0	0	51	239,038.40	1,922.90	240,961.30	51	240,961.30
8	Avon Maitland DSB	1	1,845.00	0	0	48	216,110.00	1,498.80	217,608.80	49	219,453.80
9	Greater Essex County DSB	1	6,581.00	0	0	77	445,947.20	8,105.99	454,053.19	78	460,634.19
10	Lambton Kent DSB	1	2,255.00	0	0	66	337,864.40	1,700.00	339,564.40	67	341,819.40
11	Thames Valley DSB	1	11,843.00	3	17,789.00	168	872,496.81	24,062.32	896,559.13	172	926,191.13
35	Bruce-Grey Catholic DSB	1	18,864.00	0	0	13	45,313.00	1,190.00	46,503.00	14	65,367.00
36	Huron-Perth Catholic DSB	1	11,298.00	0	0	18	49,737.80	2,232.00	51,969.80	19	63,267.80
37	Windsor-Essex Catholic DSB	1	4,167.26	0	0	50	253,117.00	8,417.46	261,534.46	51	265,701.72
38	London District Catholic School Board	1	4,065.00	1	2,380.00	54	221,084.40	11,390.40	232,474.80	56	238,919.80
39	St. Clair Catholic DSB	1	1,892.00	0	0	28	106,603.00	802.60	107,405.60	29	109,297.60
63	CSD des écoles catholiques du Sud-Ouest	1	1,094.00	7	27,251.77	28	101,150.82	2,592.00	103,742.82	36	132,088.59
East Region (4.00)		**12**	**80,416.60**	**8**	**34,074.40**	**691**	**3,457,721.52**	**130,248.92**	**3,587,970.44**	**711**	**3,702,461.44**
25	Ottawa-Carleton DSB	1	11,587.00	3	24,427.00	143	901,619.00	39,876.00	941,495.00	147	977,509.00
26	Upper Canada DSB	1	3,251.60	0	0	91	441,367.72	7,927.30	449,295.02	92	452,546.62
27	Limestone DSB	1	6,500.00	0	0	63	271,000.50	8,579.53	279,580.03	64	286,080.03
28	Renfrew County DSB	1	1,757.00	0	0	31	166,647.10	240.54	166,887.64	32	168,644.64
29	Hastings and Prince Edward DSB	1	3,809.00	0	0	55	233,175.50	3,810.00	236,985.50	56	240,794.50
52	Catholic DSB of Eastern Ontario	1	18,864.00	0	0	41	135,323.20	15,032.77	150,355.97	42	169,219.97
53	Ottawa Catholic DSB	1	7,109.00	5	9,647.40	78	481,831.40	24,212.02	506,043.42	84	522,799.82
54	Renfrew County Catholic DSB	1	763.00	0	0	23	64,574.00	350.00	64,924.00	24	65,687.00
55	Algonquin and Lakeshore Catholic DSB	1	2,421.00	0	0	41	131,431.90	8,543.40	139,975.30	42	142,396.30
59	CSD des écoles publiques de l'Est de l'Ontario	1	14,000.00	0	0	34	183,954.30	8,761.06	192,715.36	35	206,715.36
65	CSD catholique de l'Est ontarien	1	3,855.00	0	0	47	186,583.50	3,480.00	190,063.50	48	193,918.50
66	CSD catholique du Centre-Est de l'Ontario	1	6,500.00	0	0	44	260,213.40	9,436.30	269,649.70	45	276,149.70
North West Region (5.0)		**9**	**8,607.80**	**4**	**10,388.00**	**132**	**492,880.50**	**4,262.46**	**497,142.96**	**145**	**516,138.76**
5.1	Keewatin-Patricia DSB	1	896.00	2	4,027.00	23	93,656.10	644.00	94,300.10	26	99,223.10
5.2	Rainy River DSB	1	1,274.00	0	0	15	50,364.30	254.40	50,618.70	16	51,892.70
6.1	Lakehead DSB	1	2,357.00	1	1,511.00	30	134,040.50	0.00	134,040.50	32	137,908.50
6.2	Superior-Greenstone DSB	1	836.40	0	0	17	61,571.10	700.00	62,271.10	18	63,107.50
33.1	Northwest Catholic DSB	1	167.00	0	0	6	16,219.80	858.10	17,077.90	7	17,244.90
33.2	Kenora Catholic DSB	1	465.00	0	0	5	17,291.00	79.00	17,370.00	6	17,835.00
34.1	Thunder Bay Catholic DSB	1	1,865.40	0	0	20	84,768.80	1,656.96	86,425.76	21	88,291.16
34.2	Superior North Catholic DSB	1	446.00	0	0	9	18,292.10	70.00	18,362.10	10	18,808.10
62	CSD catholique des Aurores boréales	1	301.00	1	4,850.00	7	16,676.80	0.00	16,676.80	9	21,827.80

DSB No.	DSB Name	Administrative Buildings		Continuing Education Buildings		School Buildings				Total Facilities for FCA	
		Number	Area (sq.m.)	Number	Area (sq.m.)	Number	Area, Permanent Facility (sq.m.)	Area, Relocatable Classroom Module (sq.m)	Total Area (Permanent Facility + RCMs)	Number	Area (sq.m.)
North East Region (6.0)		**13**	**39,293.52**	**2**	**611.00**	**381**	**1,503,326.54**	**31,045.49**	**1,534,372.03**	**396**	**1,574,276.55**
1	DSB Ontario North East	1	2,079.00	0	0	35	154,174.00	1,367.10	155,541.10	36	157,620.10
2	Algoma DSB	1	4,234.00	0	0	51	181,159.70	1,863.00	183,022.70	52	187,256.70
3	Rainbow DSB	1	1,480.00	0	0	50	239,996.00	650.11	240,646.11	51	242,126.11
4	Near North DSB	1	1,438.00	0	0	41	176,933.60	21,754.00	198,687.60	42	200,125.60
30.1	Northeastern Catholic DSB	1	1,137.00	0	0	15	39,313.40	1,291.00	40,604.40	16	41,741.40
30.2	Nipissing-Parry Sound Catholic DSB	1	1,795.00	1	251.00	13	53,355.00	670.00	54,025.00	15	56,071.00
31	Huron-Superior Catholic DSB	1	8,996.00	0	0	25	77,259.60	852.00	78,111.60	26	87,107.60
32	Sudbury Catholic DSB	1	2,243.00	0	0	24	98,192.30	499.38	98,691.68	25	100,934.68
56	CSD du Nord-Est de l'Ontario	1	2,200.00	1	360.00	8	30,285.30	898.90	31,184.20	10	33,744.20
57	CSD du Grand Nord de l'Ontario	1	7,500.00	0	0	21	88,615.23	0.00	88,615.23	22	96,115.23
60.1	CSD catholique des Grandes Rivières	1	1,250.00	0	0	44	158,982.50	71.00	159,053.50	45	160,303.50
60.2	CSD catholique Franco-Nord	1	1,300.52	0	0	16	71,094.00	0.00	71,094.00	17	72,394.52
61	CSD catholique du Nouvel-Ontario	1	3,641.00	0	0	38	133,965.91	1,129.00	135,094.91	39	138,735.91
School Authorities		**0**	**0**	**0**	**0**	**4**	**13,685.00**	**0**	**13,685.00**	**4**	**13,685.00**
	Penetanguishene Protestant Separate School Board	0	0	0	0	1	1,660.00	0	1,660.00	1	1,660.00
	Moose Factory Island DSAB	0	0	0	0	1	4,700.00	0	4,700.00	1	4,700.00
	Moosonee DSAB	0	0	0	0	1	3,154.00	0	3,154.00	1	3,154.00
	James Bay Lowlands Secondary School Board	0	0	0	0	1	4,171.00	0	4,171.00	1	4,171.00

DSB No.	DSB Name	Facilities for New Facility Condition Assessment (NFCA)										Grand Total of Facilities for Assessment	
		Administrative Buildings		Continuing Education Buildings		School Buildings				Total Facilities for NFCA			
		Number	Area (sq.m.)	Number	Area (sq.m.)	Number	Area, Permanent Facility (sq.m.)	Area, Relocatable Classroom Module (sq.m.)	Total Area, Permanent Facility + RCM (sq.m.)	Number	Area (sq.m.)	Number	Area (sq.m)
Provincial Total		**1**	**3,994.30**	**2**	**7,205.00**	**97**	**563,846.77**	**2,512.00**	**566,358.77**	**100**	**577,558.07**	**4,923**	**26,902,920.07**
GTA Region (1.00)		**0**	**0**	**0**	**0**	**39**	**289,867.40**	**858.00**	**290,725.40**	**39**	**290,725.40**	**1,893**	**12,166,150.27**
12	Toronto District School Board	0	0	0	0	0	0	0	0	0	0.00	573	4,204,048.15
13	Durham District School Board	0	0	0	0	5	37,825.70	0	37,825.70	5	37,825.70	131	776,359.37
16	York Region DSB	0	0	0	0	12	77,562.10	0	77,562.10	12	77,562.10	192	1,338,732.70
19	Peel DSB	0	0	0	0	4	24,178.00	648.00	24,826.00	4	24,826.00	236	1,597,587.40
20	Halton DSB	0	0	0	0	3	17,130.60	0	17,130.60	3	17,130.60	98	585,892.10
40	Toronto Catholic DSB	0	0	0	0	0	0	0	0	0	0.00	223	1,130,539.70
42	York Catholic DSB	0	0	0	0	5	48,156.00	0	48,156.00	5	48,156.00	105	665,420.55
43	Dufferin-Peel Catholic DSB	0	0	0	0	5	43,679.00	140.00	43,819.00	5	43,819.00	147	961,484.00
45	Durham Catholic DSB	0	0	0	0	0	0	0	0	0	0.00	47	253,985.80
46	Halton Catholic DSB	0	0	0	0	3	27,972.00	0	27,972.00	3	27,972.00	50	315,737.60
58	CSD du Centre Sud-Ouest	0	0	0	0	1	6,749.00	0	6,749.00	1	6,749.00	41	148,677.50
64	CSD catholique Centre-Sud	0	0	0	0	1	6,615.00	70.00	6,685.00	1	6,685.00	50	187,685.40
Central Region (2.00)		**0**	**0**	**0**	**0**	**23**	**112,346.00**	**1,438.00**	**113,784.00**	**23**	**113,784.00**	**1,114**	**5,693,457.05**
14	Kawartha Pine Ridge DSB	0	0	0	0	3	8,798.00	0	8,798.00	3	8,798.00	95	430,284.20
15	Trillium Lakelands DSB	0	0	0	0		0	0	0	0	0.00	55	225,991.50
17	Simcoe County DSB	0	0	0	0	4	20,665.20	0	20,665.20	4	20,665.20	116	585,586.15
18	Upper Grand DSB	0	0	0	0	3	12,391.00	296.00	12,687.00	3	12,687.00	75	372,144.80
21	Hamilton-Wentworth DSB	0	0	0	0	2	14,044.00	0	14,044.00	2	14,044.00	122	933,376.80
22	DSB of Niagara	0	0	0	0	1	3,930.00	142.00	4,072.00	1	4,072.00	120	566,977.52
23	Grand Erie DSB	0	0	0	0	1	4,461.00	0	4,461.00	1	4,461.00	79	372,522.70
24	Waterloo Region DSB	0	0	0	0	2	11,332.00	0	11,332.00	2	11,332.00	117	673,890.38
41	Peterborough V N C Catholic DSB	0	0	0	0	0	0	0	0	0	0.00	38	174,948.77
44	Simcoe Muskoka Catholic DSB	0	0	0	0	0	0	0	0	0	0.00	54	242,058.20
47	Hamilton-Wentworth Catholic DSB	0	0	0	0	4	23,224.00	1,000.00	24,224.00	4	24,224.00	64	339,550.00
48	Wellington Catholic DSB	0	0	0	0	0	0	0	0	0	0.00	20	94,638.10
49	Waterloo Catholic DSB	0	0	0	0	1	4,837.00	0	4,837.00	1	4,837.00	58	266,553.20
50	Niagara Catholic DSB	0	0	0	0	0	0	0	0	0	0.00	66	293,952.70
51	Brant Haldimand Norfolk Catholic DSB	0	0	0	0	2	8,663.80	0	8,663.80	2	8,663.80	35	120,982.03

DSB No.	DSB Name	Administrative Buildings		Continuing Education Buildings		School Buildings				Total Facilities for NFCA		Grand Total of Facilities for Assessment	
		Number	Area (sq.m.)	Number	Area (sq.m.)	Number	Area, Permanent Facility (sq.m.)	Area, Relocatable Classroom Module (sq.m.)	Total Area, Permanent Facility + RCM (sq.m.)	Number	Area (sq.m.)	Number	Area (sq.m)
South West Region (3.0)		**1**	**3,994.30**	**2**	**7,205.00**	**14**	**58,551.14**	**216.00**	**58,767.14**	**17**	**69,966.44**	**639**	**3,133,668.77**
7	Bluewater DSB	1	3,994.30	0	0	0	0	0	0	1	3,994.30	52	244,955.60
8	Avon Maitland DSB	0	0	0	0	0	0	0	0	0	0.00	49	219,453.80
9	Greater Essex County DSB	0	0	0	0	2	12,301.40	0	12,301.40	2	12,301.40	80	472,935.59
10	Lambton Kent DSB	0	0	0	0	0	0	0	0	0	0.00	67	341,819.40
11	Thames Valley DSB	0	0	0	0	6	27,223.00	146.00	27,369.00	6	27,369.00	178	953,560.13
35	Bruce-Grey Catholic DSB	0	0	0	0	0	0	0	0	0	0.00	14	65,367.00
36	Huron-Perth Catholic DSB	0	0	0	0	0	0	0	0	0	0.00	19	63,267.80
37	Windsor-Essex Catholic DSB	0	0	0	0	1	3,403.74	0	3,403.74	1	3,403.74	52	269,105.46
38	London District Catholic School Board	0	0	0	0	1	4,640.00	0	4,640.00	1	4,640.00	57	243,559.80
39	St. Clair Catholic DSB	0	0	0	0	2	8,664.00	0	8,664.00	2	8,664.00	31	117,961.60
63	CSD des écoles catholiques du Sud-Ouest	0	0	2	7,205.00	2	2,319.00	70.00	2,389.00	4	9,594.00	40	141,682.59
East Region (4.00)		**0**	**0**	**0**	**0**	**15**	**79,889.96**	**0**	**79,889.96**	**15**	**79,889.96**	**726**	**3,782,351.40**
25	Ottawa-Carleton DSB	0	0	0	0	3	25,714.26	0	25,714.26	3	25,714.26	150	1,003,223.26
26	Upper Canada DSB	0	0	0	0	4	17,648.60	0	17,648.60	4	17,648.60	96	470,195.22
27	Limestone DSB	0	0	0	0	0	0	0	0	0	0.00	64	286,080.03
28	Renfrew County DSB	0	0	0	0	0	0	0	0	0	0.00	32	168,644.64
29	Hastings and Prince Edward DSB	0	0	0	0	0	0	0	0	0	0.00	56	240,794.50
52	Catholic DSB of Eastern Ontario	0	0	0	0	1	3,584.00	0	3,584.00	1	3,584.00	43	172,803.97
53	Ottawa Catholic DSB	0	0	0	0	4	24,769.30	0	24,769.30	4	24,769.30	88	547,569.12
54	Renfrew County Catholic DSB	0	0	0	0	0	0	0	0	0	0.00	24	65,687.00
55	Algonquin and Lakeshore Catholic DSB	0	0	0	0	0	0	0	0	0	0.00	42	142,396.30
59	CSD des écoles publiques de l'Est de l'Ontario	0	0	0	0	1	2,700.00	0	2,700.00	1	2,700.00	36	209,415.36
65	CSD catholique de l'Est ontarien	0	0	0	0	0	0	0	0	0	0.00	48	193,918.50
66	CSD catholique du Centre-Est de l'Ontario	0	0	0	0	2	5,473.80	0	5,473.80	2	5,473.80	47	281,623.50
North West Region (5.0)		**0**	**0**	**0**	**0**	**3**	**16,888.47**	**0**	**16,888.47**	**3**	**16,888.47**	**148**	**533,027.23**
5.1	Keewatin-Patricia DSB	0	0	0	0	1	253.47	0	253.47	1	253.47	27	99,476.57
5.2	Rainy River DSB	0	0	0	0	1	4,787.00	0	4,787.00	1	4,787.00	17	56,679.70
6.1	Lakehead DSB	0	0	0	0	1	11,848.00	0	11,848.00	1	11,848.00	33	149,756.50
6.2	Superior-Greenstone DSB	0	0	0	0	0	0	0	0	0	0.00	18	63,107.50
33.1	Northwest Catholic DSB	0	0	0	0	0	0	0	0	0	0.00	7	17,244.90
33.2	Kenora Catholic DSB	0	0	0	0	0	0	0	0	0	0.00	6	17,835.00
34.1	Thunder Bay Catholic DSB	0	0	0	0	0	0	0	0	0	0.00	21	88,291.16
34.2	Superior North Catholic DSB	0	0	0	0	0	0	0	0	0	0.00	10	18,808.10
62	CSD catholique des Aurores boréales	0	0	0	0	0	0	0	0	0	0.00	9	21,827.80

DSB No.	DSB Name	Administrative Buildings		Continuing Education Buildings		School Buildings				Total Facilities for NFCA		Grand Total of Facilities for Assessment	
		Number	Area (sq.m.)	Number	Area (sq.m.)	Number	Area, Permanent Facility (sq.m.)	Area, Relocatable Classroom Module (sq.m.)	Total Area, Permanent Facility + RCM (sq.m.)	Number	Area (sq.m.)	Number	Area (sq.m)
North East Region (6.0)		0	0	0	0	3	6,303.80	0	6,303.80	3	6,303.80	399	1,580,580.35
1	DSB Ontario North East	0	0	0	0	0	0	0	0	0	0.00	36	157,620.10
2	Algoma DSB	0	0	0	0	0	0	0	0	0	0.00	52	187,256.70
3	Rainbow DSB	0	0	0	0	1	1,784.80	0	1,784.80	1	1,784.80	52	243,910.91
4	Near North DSB	0	0	0	0	1	1,067.00	0	1,067.00	1	1,067.00	43	201,192.60
30.1	Northeastern Catholic DSB	0	0	0	0	0	0	0	0	0	0.00	16	41,741.40
30.2	Nipissing-Parry Sound Catholic DSB	0	0	0	0	0	0	0	0	0	0.00	15	56,071.00
31	Huron-Superior Catholic DSB	0	0	0	0	0	0	0	0	0	0.00	26	87,107.60
32	Sudbury Catholic DSB	0	0	0	0	0	0	0	0	0	0.00	25	100,934.68
56	CSD du Nord-Est de l'Ontario	0	0	0	0	0	0	0	0	0	0.00	10	33,744.20
57	CSD du Grand Nord de l'Ontario	0	0	0	0	0	0	0	0	0	0.00	22	96,115.23
60.1	CSD catholique des Grandes Rivières	0	0	0	0	0	0	0	0	0	0.00	45	160,303.50
60.2	CSD catholique Franco-Nord	0	0	0	0	1	3,452.00	0	3,452.00	1	3,452.00	18	75,846.52
61	CSD catholique du Nouvel-Ontario	0	0	0	0	0	0	0	0	0	0.00	39	138,735.91
School Authorities		0	0	0	0	0	0	0	0	0	0	4	13,685.00
	Penetanguishene Protestant Separate School Board	0	0	0	0	0	0	0	0	0	0.00	1	1,660.00
	Moose Factory Island DSAB	0	0	0	0	0	0	0	0	0	0.00	1	4,700.00
	Moosonee DSAB	0	0	0	0	0	0	0	0	0	0.00	1	3,154.00
	James Bay Lowlands Secondary School Board	0	0	0	0	0	0	0	0	0	0.00	1	4,171.00

Appendix B
Modified Uniformat II List of Components

UNIFORMAT II				Components to be Assessed for a Full Facility Condition Assessment	Components to be Assessed for a New School Condition Assessment
Level 1 Major Group Components	Level 2 Group Elements	Level 3 Individual Elements	Level 4 Sub-Elements		
A Substructure				x	
	A10 Foundations		*(To assess visible level 4 elements)*	x	
		A1010 Standard Foundations		x	
			A101001 Wall Foundations	x	
			A101002 Column Foundations and Pile Caps	x	
			A101003 Dewatering	x	
			A101099 Other Standard Foundations	x	
		A1020 Special Foundations		x	
			A102001 Pile Foundations	x	
			A102002 Caissons	x	
			A102003 Underpinning	x	
			A102004 Dewatering	x	
			A102005 Raft Foundations	x	
			A102006 Pressure Injected Grouting	x	
			A102099 Other Special Foundations	x	
		A1030 Slab on Grade		x	
			A103001 Standard Slab on Grade	x	
			A103002 Structural Slab on Grade	x	
			A103003 Inclined Slab on Grade	x	
			A103004 Trenches	x	
			A103005 Pits and Bases	x	
			A103006 Foundation Drainage	x	
			A103099 Other Slab on Grade	x	
	A 20 Basement Construction		*(To assess visible level 4 elements)*	x	
		A2010 Basement Excavation		x	
			A201001 Excavation for Basements		
			A201002 Structure Backfill and Compaction		
			A201003 Shoring		
			A201099 Other Basement Excavation		
		A2020 Basement Walls		x	

UNIFORMAT II				Components to be Assessed for a Full Facility Condition Assessment	Components to be Assessed for a New School Condition Assessment
Level 1 Major Group Components	Level 2 Group Elements	Level 3 Individual Elements	Level 4 Sub-Elements		
			A202001 Basement Wall Construction	x	
			A202002 Moisture Protection	x	
			A202003 Basement Wall Insulation	x	
			A202099 Other Basement Walls	x	
B Shell				x	
	B10 Superstructure		*(To assess visible level 4 elements)*	x	
		B1010 Floor Construction		x	
			B101001 Structural Frame	x	
			B101002 Structural Interior Walls	x	
			B101003 Floor Decks and Slabs		
			B101004 Balcony Construction	x	
			B101005 Ramps	x	
			B101006 Floor Raceway Systems		
			B101007 Inclined and Stepped Floors	x	
			B101099 Other Floor Construction	x	
		B1020 Roof Construction		x	
			B102001 Structural Frame	x	
			B102002 Structural Interior Walls	x	
			B102003 Roof Decks and Slabs	x	
			B102004 Canopies	x	
			B102099 Other Roof Construction	x	
	B20 Exterior Enclosure			x	
		B2010 Exterior Walls		x	
			B201001 Exterior Closure	x	
			B201002 Exterior Walls Backup Construction		
			B201003 Insulation and Vapor Retarder		
			B201004 Parapets	x	
			B201005 Exterior Louvers and Screens	x	
			B201006 Sun Control Devices (Exterior)	x	
			B201007 Balcony Walls and Railings	x	
			B201008 Exterior Soffits	x	
			B201009 Screen Wall	x	
			B201010 Exterior Coatings	x	
			B201011 Joint Sealant	x	
			B201099 Other Exterior Walls	x	
		B2020 Exterior Windows		x	
			B202001 Windows	x	
			B202002 Storefronts	x	
			B202003 Curtain Walls	x	
			B202004 Exterior Glazing	x	

UNIFORMAT II				Components to be Assessed for a Full Facility Condition Assessment	Components to be Assessed for a New School Condition Assessment
Level 1 Major Group Components	Level 2 Group Elements	Level 3 Individual Elements	Level 4 Sub-Elements		
			B202099 Other Exterior Windows	x	
		B2030 Exterior Doors		x	
			B203001 Solid Doors	x	
			B203002 Glazed Doors	x	
			B203003 Revolving Doors	x	
			B203004 Overhead and Roll-up Doors	x	
			B203005 Hangar Doors		
			B203006 Blast Resistant Doors	x	
			B203007 Gates	x	
			B203008 Exterior Door Hardware	x	
			B203098 Other Exterior Specialty Doors	x	
			B203099 Other Exterior Personnel Doors	x	
B Shell	B30 Roofing			x	x
		B3010 Roof Coverings		x	x
			B301001 High Slope Roof Coverings	x	x
			B301002 Low Slope Membrane Systems	x	x
			B301003 Roof Insulation and Fill		
			B301004 Flashings and Trim	x	x
			B301005 Gutters and Downspouts	x	x
			B301006 Roof Openings and Supports	x	x
			B301099 Other Roofing	x	x
C Interiors				x	
	C10 Interior Construction			x	
		C1010 Partitions		x	
			C101001 Fixed Partitions	x	
			C101002 Demountable Partitions		
			C101003 Retractable Partitions	x	
			C101004 Interior Guardrails and Screens		
			C101005 Interior Windows	x	
			C101006 Glazed Partitions and Storefronts	x	
			C101007 Interior Glazing	x	
			C101008 Joint Sealant	x	
			C101099 Other Partitions	x	
		C1020 Interior Doors		x	
			C102001 Standard Interior Doors	x	
			C102002 Glazed Interior Doors	x	
			C102003 Fire Doors	x	
			C102004 Sliding and Folding Doors	x	
			C102005 Interior Overhead Doors	x	
			C102006 Interior Gates	x	
			C102007 Interior Door Hardware	x	
			C102098 Other Interior Specialty Doors	x	
			C102099 Other Interior Personnel Doors	x	

UNIFORMAT II				Components to be Assessed for a Full Facility Condition Assessment	Components to be Assessed for a New School Condition Assessment
Level 1 Major Group Components	Level 2 Group Elements	Level 3 Individual Elements	Level 4 Sub-Elements		
		C1030 Fittings		x	
			C103001 Compartments, Cubicles and Toilet Partitions	x	
			C103002 Toilet and Bath Accessories	x	
			C103003 Marker Boards and Tack Boards	x	
			C103004 Identifying Devices		
			C103005 Lockers	x	
			C103006 Shelving		
			C103007 Fire Extinghuisher Cabinets	x	
			C103008 Counters	x	
			C103009 Cabinets	x	
			C103010 Closets	x	
			C103011 Firestopping Penetrations	x	
			C103012 Sprayed Fire-Resistive Materials	x	
			C103013 Raised Access Flooring		
			C103014 Casework		
			*C103015 Chalk boards	x	
			C103099 Other Interior Specialties	x	
	C20 Stairs			x	
		C2010 Stair Construction		x	
			C201001 Interior Stair Construction	x	
			C201002 Exterior Stair Construction	x	
			C201099 Other Stair Construction	x	
		C2020 Stair Finishes		x	
			C202001 Interior Stair Finish	x	
	C30 Interior Finishes			x	
		C3010 Wall Finishes		x	
			C301001 Concrete Wall Finishes	x	
			C301002 Plaster Wall Finishes	x	
			C301003 Gypsum Wallboard Finishes	x	
			C301004 Tile and Terrazzo Wall Finishes	x	
			C301005 Painting to Walls	x	
			C301006 Wall Coverings	x	
			C301007 Acoustical Panels Adhered to Walls	x	
			C301008 Special Coatings to Walls	x	
			C301099 Other Wall Finishes	x	
		C3020 Floor Finishes		x	
			C302001 Tile Floor Finishes	x	
			C302002 Terrazzo Floor Finishes	x	
			C302003 Wood Flooring	x	
			C302004 Resilient Floor Finishes	x	

UNIFORMAT II				Components to be Assessed for a Full Facility Condition Assessment	Components to be Assessed for a New School Condition Assessment
Level 1 Major Group Components	Level 2 Group Elements	Level 3 Individual Elements	Level 4 Sub-Elements		
			C302005 Carpeting	x	
			C302006 Masonry and Stone Flooring	x	
			C302007 Painting and Staining Floors		
			C302008 Wall Base Finishes	x	
			C302009 Floor Toppings and Traffic Membranes	x	
			C302010 Hardeners and Sealers	x	
			C302099 Other Flooring and Floor Finishes	x	
		C3030 Ceiling Finishes		x	
			C303001 Exposed Concrete Finishes	x	
			C303002 Plaster Ceiling Finishes	x	
			C303003 Gypsum Wallboard Ceiling Finishes	x	
			C303004 Acoustical Ceiling Tiles and Panels	x	
			C303005 Wood Ceilings	x	
			C303006 Painting and Staining Ceilings	x	
			C303007 Suspensions Systems	x	
			C303008 Metal Strip Ceilings	x	
			C303099 Other Ceiling and Ceiling Finishes	x	
D Services				x	x
	D10 Conveying			x	x
		D1010 Elevators and Lifts		x	x
			D101001 General Construction Items		
			D101002 Passenger Elevators	x	x
			D101003 Freight Elevators	x	x
			D101004 Wheelchair Lift	x	x
			D101099 Other Elevators	x	x
		D1020 Escalators and Moving Walks			
			D102001 Moving Stairs		
			D102002 Moving Walks		
			D102099 Other Moving Stairs and Walks		
		D1030 Other Conveying Systems		x	x
			D109001 Pneumatic Tube Systems		
			D109002 Conveyors		
			D109003 Linen, Trash, and Mail Chutes		
			D109004 Turntables		
			D109005 Operable Scaffolding		
			D109006 Transportation Systems		
			D109007 Overhead Cranes		
			D109099 Other Material and Handling Systems		
	D20 Plumbing			x	x

UNIFORMAT II				Components to be Assessed for a Full Facility Condition Assessment	Components to be Assessed for a New School Condition Assessment
Level 1 Major Group Components	Level 2 Group Elements	Level 3 Individual Elements	Level 4 Sub-Elements		
		D2010 Plumbing Fixtures		x	x
			D201001 Waterclosets	x	x
			D201002 Urinals	x	x
			D201003 Lavatories	x	x
			D201004 Sinks	x	x
			D201005 Showers/Tubs	x	x
			D201006 Drinking Fountains and Coolers	x	x
			D201007 Bidets	x	x
			D201099 Emergency Fixtures	x	x
		D2020 Domestic Water Distribution		x	x
			D202001 Pipes and Fittings	x	x
			D202002 Valves and Hydrants	x	x
			D202003 Domestic Water Equipment	x	x
			D202004 Insulation and Identification	x	x
			D202005 Specialties	x	x
			D202099 Other Domestic Water Supply	x	x
		D2030 Sanitary Waste		x	x
			D203001 Waste Pipe and Fittings		
			D203002 Vent Pipe and Fittings		
			D203003 Floor Drains	x	x
			D203004 Sanitary and Vent Equipment		
			D203005 Insulation and Identification		
			D203099 Other Sanitary Waste		
		D2040 Rain Water Drainage		x	x
			D204001 Pipe and Fittings	x	x
			D204002 Roof Drains	x	x
			D204003 Rainwater Drainage Equipment	x	x
			D204004 Insulation and Identification		
			D204099 Other Rain Water Drainage System		
		D2050 Other Plumbing		x	x
			D209001 Special Piping Systems		
			D209002 Acid Waste Systems	x	x
			D209003 Interceptors	x	x
			D209004 Pool Piping and Equipment (if visible)	x	x
			D209005 Compressed Air System (Non-Breathing)		
			D209099 Other Special Plumbing Systems	x	x
	D30 HVAC			x	x
		D3010 Energy Supply	*(To assess visible Level 4 elements)*	x	x
			D301001 Oil Supply System	x	x
			D301002 Gas Supply System	x	x

UNIFORMAT II				Components to be Assessed for a Full Facility Condition Assessment	Components to be Assessed for a New School Condition Assessment
Level 1 Major Group Components	Level 2 Group Elements	Level 3 Individual Elements	Level 4 Sub-Elements		
			D301003 Coal Supply System		
			D301004 Steam Supply System (From Central Plant)	x	x
			D301005 Hot Water Supply System (From Central Plant)	x	x
			D301006 Solar Energy Supply Systems	x	x
			D301007 Wind Energy Supply System	x	x
			D301099 Other Energy Supply	x	x
		D3020 Heat Generating		x	x
			D302001 Steam Boilers	x	x
			D302002 Hot Water Boilers	x	x
			D302003 Furnaces	x	x
			D302004 Fuel-Fired Unit Heaters	x	x
			D302005 Auxiliary Equipment	x	x
			D302006 Equipment Thermal Insulation	x	x
			D302009 Other Heat Generating Systems	x	x
		D3030 Cooling Generating Systems		x	x
			D303001 Chilled Water Systems	x	x
			D303002 Direct Expansion Systems	x	x
			D303099 Other Cooling Generating Systems	x	x
		D3040 Distribution Systems	*(To assess visible Level 4 elements)*	x	x
			D304001 Air Distribution, Heating and Cooling	x	x
			D304002 Steam Distribution Systems	x	x
			D304003 Hot Water Distribution Systems	x	x
			D304004 Change over Distribution Systems	x	x
			D304005 Glycol Distribution Systems	x	x
			D304006 Chilled Water Distribution Systems	x	x
			D304007 Exhaust Systems	x	x
			D304008 Air Handling Units	x	x
			D304099 Other Distribution Systems	x	x
		D3050 Terminal and Package Units		x	x
			D305001 Unit Ventilators	x	x
			D305002 Unit Heaters	x	x
			D305003 Fan Coil Units	x	x
			D305004 Fin Tube Radiation	x	x
			D305005 Electric Heating	x	x
			D305006 Package Units	x	x
			D305099 Other Terminal and Package Units	x	x
		D3060 Controls and Instrumentation		x	x
			D306001 HVAC Controls	x	x

UNIFORMAT II				Components to be Assessed for a Full Facility Condition Assessment	Components to be Assessed for a New School Condition Assessment
Level 1 Major Group Components	Level 2 Group Elements	Level 3 Individual Elements	Level 4 Sub-Elements		
			D306002 Electronic Controls	x	x
			D306003 Pneumatic Controls	x	x
			D306004 Instrument Air Compressors	x	x
			D306005 Gas Purging Systems	x	x
			D306099 Other Controls Instrumentation	x	x
		D3070 Systems Testing and Balancing		x	x
			D307001 Water Side Testing and Balancing - Heating and Cooling		
			D307002 Air Side Testing and Balancing - Heating, Cooling and Exhaust		
			D307003 HVAC Commissioning		
			D307099 Other Systems Testing and Balancing		
		D3090 Other HVAC Systems and Equipment		x	x
			D309001 General Construction Items		
			D309002 Refrigeration Systems	x	x
			D309099 Other Special Mechanical Systems	x	x
	D40 Fire Protection		*(To assess visible Level 4 elements)*	x	x
		D4010 Sprinkels		x	x
			D401001 Sprinkels and Releasing Devices	x	x
			D401002 Sprinkler Water Supply Equipment and Piping	x	x
		D4020 Standpipe Systems		x	x
			D402001 Standpipe Equipment and Piping	x	x
		D4030 Fire Protection Specialties		x	x
			D403001 Fire Extinguishing Devices	x	x
		D4090 Other Fire Protection Systems		x	x
			D409001 Carbon Dioxide Systems	x	x
			D409002 Foam Generating Equipment	x	x
			D409003 Clean Agent Systems	x	x
			D409005 Hood and Duct Fire Protection	x	x
			D409099 Other Special Fire Protection Systems	x	x
	D50 Electrical		*(To assess visible Level 4 elements)*	x	x
		D5010 Electral Service and Distribution		x	x
			D501001 Main Transformers	x	x
			D501002 Secondary	x	x
			D501003 Main Switchboards	x	x

UNIFORMAT II				Components to be Assessed for a Full Facility Condition Assessment	Components to be Assessed for a New School Condition Assessment
Level 1 **Major Group Components**	**Level 2** **Group Elements**	**Level 3** **Individual Elements**	**Level 4** **Sub-Elements**		
			D501004 Interior Distribution Transformers	x	x
			D501005 Panels	x	x
			D501006 Enclosed Circuit Breakers	x	x
			D501007 Motor Control Centers	x	x
			D501099 Other Service and Distribution	x	x
		D5020 Lighting and Branch Wiring			
			D502001 Branch Wiring		
			D502002 Lighting Equipment		
			D502099 Other Lighting and Branch Wiring		
		D5030 Communications and Security	*(To assess visible Level 4 elements)*	x	x
			D503001 Fire Alarm Systems	x	x
			D503002 Telecommuncations Systems	x	x
			D503003 Nurse Call Systems	x	x
			D503004 Public Address Systems	x	x
			D503005 Intercommunications Systems	x	x
			D503006 Clock and Program Systems	x	x
			D503007 Television Systems	x	x
			D503008 Security Systems	x	x
			D503099 Other Communications and Alarm Systems	x	x
		D5090 Other Electrical		x	x
			D509001 General Construction Items (Electrical)		
			D509002 Emergency Lighting and Power	x	x
			D509003 Grounding Systems	x	x
			D509004 Lightning Protection	x	x
			D509005 Electric Heating	x	x
			D509006 Energy Management Control System	x	x
			D509099 Other Special Systems and Devices	x	x
E Equipment and Furnishings				x	
	E10 Equipment			x	
		E1010 Commercial Equipment		x	
			E101001 Checkroom Equipment		
			E101002 Registration Equipment		
			E101003 Vending Equipment		
			E101004 Laundry Equipment		

UNIFORMAT II				Components to be Assessed for a Full Facility Condition Assessment	Components to be Assessed for a New School Condition Assessment
Level 1 Major Group Components	Level 2 Group Elements	Level 3 Individual Elements	Level 4 Sub-Elements		
			E101005 Security and Vault Equipment		
			E101006 Teller and Service Equipment		
			E101007 Mercantile Equipment		
			E101008 Office Equipment		
		E1020 Institutional Equipment			
			E102001 Miscellaneous Common Fixed and Moveable Equipment		
			E102002 Medical Equipment		
			E102003 Laboratory Equipment		
			E102004 Mortuary Equipment		
			E102005 Auditorium and Stage Equipment	x	
			E102006 Library Equipment		
			E102007 Ecclesiastical Equipment		
			E102008 Instrumental Equipment		
			E102009 Audio-Visual Equipment		
			E102010 Detention Equipment		
		E1030 Vehicular Equipment			
			E103001 Parking Control Equipment		
			E103002 Loading Dock Equipment		
			E103003 Warehouse Equipment		
		E1090 Other Equipment		x	
			E109001 Built-in Maintenance Equipment		
			E109002 Food Service Equipment		
			E109003 Waste Handling Equipment		
			E109004 Residential Equipment		
			E109005 Unit Kitchens		
			E109006 Darkroom Equipment		
			E109007 Athletic, Recreational, and Therapeutic Equipment	x	
			E109008 Planetarium Equipment		
			E109009 Observatory Equipment		
			E109010 Agricultural Equipment		
			E109099 Other Specialized Fixed and Moveable Equipment		
	E20 Furnishings			x	
		E2010 Fixed Furnishings		x	
			E201001 Fixed Artwork		
			E201002 Window Treatments	x	
			E201003 Seating (Fixed)	x	
			E201004 Fixed Floor Grilles and Mats	x	
			E201005 Fixed Interior Landscaping		

UNIFORMAT II				Components to be Assessed for a Full Facility Condition Assessment	Components to be Assessed for a New School Condition Assessment
Level 1 Major Group Components	Level 2 Group Elements	Level 3 Individual Elements	Level 4 Sub-Elements		
			E201099 Other Fixed Interior Furnishings	x	
		E2020 Moveable Furnishings			
			E202001 Moveable Artwork		
			E202002 Modular Prefabricated Furniture		
			E202003 Freestanding Furniture		
			E202004 Rugs and Accessories		
			E202005 Moveable Multiple Seating		
			E202006 Moveable Interior Landscaping		
			E202099 Other Moveable Furnishings		
F Special Construction and Demolition					
	F10 Special Construction				
		F1010 Special Structures			
			F101001 Metal Building Systems		
			F101002 Exterior Utility Buildings		
			F101003 Air-Supported Structures		
			F101099 Other Special Construction		
		F1020 Integrated Construction		x	
			F102001 Special Purpose Rooms	x	
			F102002 Integrated Assemblies		
			F102099 Other Integrated Construction	x	
		F1030 Special Construction Systems			
			F103001 Vaults		
			F103002 Sound, Vibration and Seismic Construction		
			F103003 Radiation Protection		
			F103099 Other Special Construction Systems		
		F1040 Special Facilities			
			F104001 Interior Swimming Pools	x	
			F104002 Liquid and Gas Storage Tanks		
			F104003 Kennels and Animal Shelters		
			F104004 Site Constructed Incinerators		
			F104005 Ice Rinks		
			F104099 Other Special Facilities		
		F1050 Special Controls and Instrumentation			
			F105001 Recording Instrumentation		
			F105002 Building Automation Systems	x	

UNIFORMAT II				Components to be Assessed for a Full Facility Condition Assessment	Components to be Assessed for a New School Condition Assessment
Level 1 Major Group Components	Level 2 Group Elements	Level 3 Individual Elements	Level 4 Sub-Elements		
			F105099 Other Special Controls and Instrumentation	x	
	F20 Selective Building Demolition				
		F2010 Building Elements Demolition			
			F201001 Substructure and Superstructure		
			F201002 Exterior Closure		
			F201003 Roofing		
			F201004 Interior Construction and Finishes		
			F201005 Conveying Systems		
			F201006 Mechanical Systems		
			F201007 Electrical Systems		
			F201008 Equipment and Furnishings		
			F201099 Other Non-Hazardous Selective Building Demolition		
		F2020 Hazardous Components Abatement	*Note: Includes removal or encapsulation of hazardous building materials and components*	x	
			F202001 Substructure and Superstructure		
			F202002 Exterior Closure		
			F202003 Roofing		
			F202004 Interior Consturction and Finishes		
			F202005 Conveying Sytems		
			F202006 Mechanical Systems		
			F202007 Electrical Systems		
			F202008 Equipment and Furnishings		
			F202099 Other Hazardous Selective Building Demolition		
G Building Sitework				x	x
	G10 Site Preparation				
		G1010 Site Clearing			
			G101001 Clearing		
			G101002 Tree Removal		
			G101003 Stump Removal		
			G101004 Chipping		
			G101005 Grubbing		
			G101006 Selective Thinning		
			G101007 Debris Disposal		
			G101099 Other Site Clearing		
		G1020 Site Demolition and Relocations			
			G102001 Building Mass Demolition		
			G102002 Above Ground Site Demolition		
			G102003 Underground Site Demolition		
			G102004 Buidling Relocation		

UNIFORMAT II				Components to be Assessed for a Full Facility Condition Assessment	Components to be Assessed for a New School Condition Assessment
Level 1	Level 2	Level 3	Level 4		
Major Group Components	Group Elements	Individual Elements	Sub-Elements		
			G102005 Utility Relocation		
			G102006 Fencing Relocation		
			G102007 Site Cleanup		
			G102099 Other Site Demolition and Relocations		
		G1030 Site Earthwork			
			G103001 Grading		
			G103002 Common Excavation		
			G103003 Rock Excavation		
			G103004 Fill and Borrow		
			G103005 Compaction		
			G103006 Soil Stabilization		
			G103007 Slope Stabilization		
			G103008 Soil Treatment		
			G103009 Shoring		
			G103010 Temporary Dewatering		
			G103011 Temporary Erosion and Sediment Control		
			G103099 Other Site Earthwork		
		G1040 Hazardous Waste Reduction			
			G104001 Removal of Contaminated Soil		
			G104002 Soil Restoration and Treatment		
			G104099 Other Hazardous Waste Remediation		
	G20 Site Improvements			x	
		G2010 Roadways		x	
			G201001 Bases and Subbases		
			G201002 Curbs and Gutters	x	
			G201003 Paved Surfaces	x	
			G201004 Marking and Signage		
			G201005 Guardrails and Barriers	x	
			G201006 Resurfacing	x	
			G201099 Other Roadways	x	
		G2020 Parking Lots		x	
			G202001 Bases and Subbases		
			G202002 Curbs and Gutters	x	
			G202003 Paved Surfaces	x	
			G202004 Marking and Signage		
			G202005 Guardrails and Barriers	x	
			G202006 Resurfacing	x	
			G202007 Miscellaneous Structures and Equipment	x	
			G202099 Other Parking Lots	x	
		G2030 Pedestrian Paving		x	
			G203001 Bases and Subbases		
			G203002 Curb and Gutters	x	
			G203003 Paved Surfaces	x	
			G203004 Guardrails and Barriers	x	
			G203005 Resurfacing	x	
			G203099 Other Walks, Steps and Terraces	x	
		G2040 Site Development		x	
			G204001 Fencing and Gates	x	

UNIFORMAT II				Components to be Assessed for a Full Facility Condition Assessment	Components to be Assessed for a New School Condition Assessment
Level 1 Major Group Components	Level 2 Group Elements	Level 3 Individual Elements	Level 4 Sub-Elements		
			G204002 Retaining Walls	x	
			G204003 Exterior Furnishings		
			G204004 Security Structures		
			G204005 Signage		
			G204006 Fountains and Pools		
			G204007 Playing Fields	x	
			G204008 Terrace and Perimeter Walls	x	
			G204009 Flagpoles		
			G204099 Other Site Improvements		
		G2050 Landscaping		x	
			G205001 Fine Grading and Soil Preparation		
			G205002 Erosion Control Measures		
			G205003 Topsoil and Planting Beds		
			G205004 Seeding, Sprigging and Sodding		
			G205005 Planting		
			G205006 Planters		
			G205007 Irrigation Systems	x	
			G205099 Other Landscaping		
	G30 Site/Civil Mechanical Utilities			x	x
		G3010 Water Supply		x	x
			G301001 Well Systems	x	x
			G301002 Potable Water Distribution	x	x
			G301003 Potable Water Storage	x	x
			G301004 Fire Protection Water Distribution	x	x
			G301005 Fire Protection Water Storage	x	x
			G301006 Non-Potable Water Distribution	x	x
			G301007 Pumping Stations	x	x
			G301008 Packaged Water Treatment Plants	x	x
			G301099 Other Water Supply	x	x
		G3020 Sanitary Sewer		x	
			G302001 Sanitary Sewer Piping		
			G302002 Sanitary Sewer Manholes and Cleanouts		
			G302003 Lift Stations and Pumping Stations		
			G302004 Packaged Sanitary Sewer Treatment Plants		
			G302005 Septic Tanks	x	
			G302006 Drain Fields	x	
			G302099 Other Sanitary Sewer	x	
		G3030 Storm Sewer		x	
			G303001 Storm Sewer Piping		
			G303002 Storm Sewer Structures		
			G303003 Lift Stations		
			G303004 Culverts	x	
			G303005 Headwalls	x	

UNIFORMAT II				Components to be Assessed for a Full Facility Condition Assessment	Components to be Assessed for a New School Condition Assessment
Level 1 **Major Group Components**	**Level 2** **Group Elements**	**Level 3** **Individual Elements**	**Level 4** **Sub-Elements**		
			G303006 Erosion and Sediment Control Measures	x	
			G303007 Stormwater Management	x	
			G303099 Other Storm Sewer	x	
		G3040 Heating Distribution	*(To assess visible Level 4 elements)*	x	x
			G304001 Overhead Hot Water Systems	x	x
			G304002 Overhead Steam Systems	x	x
			G304003 Underground Hot Water Systems	x	x
			G304004 Underground Steam Distribution Systems	x	x
			G304005 Reinforced Concrete Manholes and Valve Boxes	x	x
			G304006 Pumping Stations	x	x
			G304099 Other Heating Distribution	x	x
		G3050 Cooling Distribution	*(To assess visible Level 4 elements)*	x	x
			G305001 Overhead Cooling Systems		
			G305002 Underground Cooling Systems		
			G305003 Trenchboxes		
			G305004 Wells for Cooling		
			G305005 Pumping Stations		
			G305006 On-Site Cooling Towers		
			G305099 Other Cooling Distribution		
		G3060 Fuel Distribution		x	
			G306001 Liquid Fuel Distribution Piping	x	
			G306002 Aviation Fuel Distribution Piping System		
			G306003 Liquid Fuel Dispensing Equipment	x	
			G306004 Liquid Fuel Storage Tanks	x	
			G306005 Liquid Fuel System Trenchboxes	x	
			G306006 Gas Distribution Piping (Natural and Propane)	x	
			G306007 Gas Storage Tanks	x	
			G306008 Gas System Trenchboxes	x	
			G306098 Other Gas Distribution	x	
			G306099 Other Fuel Distribution	x	
		G3090 Other Site Mechanical Utilities		x	
			G309001 Industrial Waste Pipe		
			G309002 Industrial Waste Manholes and Cleanouts		
			G309003 Industrial Waste Lift Stations		
			G309004 Industrial Waste Holding Tanks and Separators		

UNIFORMAT II				Components to be Assessed for a Full Facility Condition Assessment	Components to be Assessed for a New School Condition Assessment
Level 1 Major Group Components	Level 2 Group Elements	Level 3 Individual Elements	Level 4 Sub-Elements		
			G309005 Industrial Waste Trenchboxes		
			G309099 Other Industrial Waste		
	G40 Site Electrical Utilities			x	x
		G4010 Electrical Distribution		x	x
			G401001 Substations	x	x
			G401002 Transformers	x	x
			G401003 Switches, Controls and Devices	x	x
			G401004 Overhead Electric Conductors	x	x
			G401005 Towers, Poles, Crossarms and Insulations		
			G401006 Underground Electric Conductors		
			G401007 Ductbanks, Manholes, Handholes and Raceways		
			G401008 Grounding Systems	x	x
			G401009 Metering	x	x
			G401099 Other Electric Transmission and Distribution		
		G4020 Site Lighting		x	
			G402001 Tranformers	x	x
			G402002 Overhead Electric Conductors	x	x
			G402003 Towers, Poles, Crossarms and Insulations	x	x
			G402004 Underground Electirc Conductors		
			G402005 Ductbanks, Manholes and Handholes		
			G402006 Exterior Lighting Fixtures and Controls	x	x
			G402007 Grounding Systems	x	x
			G402008 Special Security Lighting Systems	x	x
			G402099 Other Area Ligthing	x	x
		G4030 Site Communications and Security		x	
			G403001 Telecommunications Systems		
			G403002 Sound Systems		
			G403003 Fire Alarm Systems		
			G403004 Cable TV Systems (CATV)		
			G403005 Cables and Wirings		
			G403006 Ductbanks, Manholes and Handoles		
			G403007 Towers, Poles and Stands		
			G403008 TV Cameras and Monitors	x	
			G403009 Grounding Systems		
			G403098 Other Communication and Alarm		

UNIFORMAT II				Components to be Assessed for a Full Facility Condition Assessment	Components to be Assessed for a New School Condition Assessment
Level 1 Major Group Components	Level 2 Group Elements	Level 3 Individual Elements	Level 4 Sub-Elements		
			G403099 Other Security Systems		
		G4090 Other Site Electrical Utilities		x	
			G409001 Sacrificial Anode Cathodic Protection System		
			G409002 Induced Current Cathodic Protection System		
			G409003 Emergency Power Generation		
			G409099 Other Cathodic Protection		
	G90 Other Site Construction			x	
		G9010 Service and Pedestrian Tunnels		x	
			G901001 Construction of Service and Pedestrian Tunnels		
			G901002 Prefabricated Service and Pedestrian Tunnels		
		G9090 Other Site Construction			
			G909001 Bridges		
			G909002 Railroad Spurs		
			G909003 Snow Melting Systems		
			G909099 Other Special Construction		
H Land					
	H10 Land				
		H1010 Land			