

# COMPUTER DATA BASE USE IN THE ANALYSIS OF ROOFING SYSTEM PERFORMANCE AND DESIGN FOR NEW YORK STATE OWNED BUILDINGS

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Computer data base technology presents the Design and Construction Group of the New York State Office of General Services with opportunities to improve on the selection of roofing materials and the design of roofing systems. This paper reviews progress made in the development of this office's roofing materials and systems data base (ROOFDATA).

The purpose of this data base is to provide information which will assist in roofing system design. This is accomplished by tracking roofing performance from conception of a project throughout the lifetime of the newly installed system. ROOFDATA is used to maintain a history of roofing materials and systems performance.

The system provides performance analysis through the selection and cross-reference of available data fields. By proper utilization of information, design decisions on future projects will be positively affected. ROOFDATA provides access to information on design, specifications, contractual data, field tests, field conditions, problems and their resolution.

Currently this roofing system performance data base contains records of 750 projects. ROOFDATA will grow through the annual addition of data from 100 to 125 roofing projects. With over 10,000 state-owned buildings, in over 800 locations, the data base will increase in value over time.

## KEYWORDS

Data base system, New York state government buildings, roofing systems performance analysis.

## INTRODUCTION

This paper reviews the progress made by the New York state Office of General Services (OGS) in the development of its roofing materials and systems data base (ROOFDATA). ROOFDATA will be part of an overall data base management system.

New York state government includes over 50 departments, agencies, divisions, commissions and offices. The facilities they occupy consist of approximately 10,000 buildings at over 800 locations scattered across the state. When in need of new building construction or renovation of existing structures, these organizations seek the professional assistance of the Office of General Services, Design and Construction Group. This organization is charged with the professional responsibility of providing building design and construction inspection. The maintenance and replacement of the roofs for these buildings is the concern of this research.

OGS has the responsibility to serve "as a management tool for the Executive branch"<sup>1</sup> by assisting state agencies with the facilities management of New York state government's physical plant. This includes assisting in meeting the needs of client agencies by providing the design and construction inspection of both new buildings, and restoration, remodeling and modernization of existing buildings.

The need to understand how to maximize the performance of roofing systems is the genesis for the ROOFDATA data base. This computer data base system is designed as an applied research tool in response to the present and future needs of a state government's design and construction organization. Proper utilization of information stemming from this research will result in improved roofing system design.

The Design and Construction Group provides architectural, engineering and construction management services. This group is a multidisciplinary professional organization employing over 700 people including architects, engineers, landscape architects, surveyors, estimators, construction inspectors and other support and administrative staff. After being initiated by a client agency, a project's programmatic needs are evaluated, a design is executed, and contract documents are prepared. These contract documents are put out to public bid. Construction supervision is provided by OGS inspectors.

In a recent national survey,<sup>2</sup> the New York State Office of General Services, Design and Construction Group was ranked 13th nationally among government agencies, with construction values approaching \$400,000,000 per year. More than 50 percent of the design work, but no construction, was done in-house. The Design and Construction Group accepts approximately 550 projects annually from over 20 of the largest state agencies. Approximately 90 percent of the projects are rehabilitation work, while the remaining 10 percent are new construction projects. In dollar terms, approximately 85 percent is spent on new construction and 15 percent on rehabilitation. During a typical fiscal year, the Design and Construction Group bids 100 to 125 roof-related projects with a dollar value in excess of \$12,000,000.

## HISTORIC DEVELOPMENT

The Office of Research, Materials and Systems Coordination (ORMSC) is an office within the Design and Construction Group. One of the duties of this office is to provide building materials and systems research across the fields of

architecture and engineering. This office supervises the design of roofing projects, and is responsible for the specification of roofing materials and systems. Roofing problems occurring during the course of construction are frequently resolved through the active intervention of the ORMSC staff.

It is intended that each roofing project benefit from the ready accessibility of the latest information on both new technology and established building methodology and materials. With the large number of roofing materials used in the construction and maintenance of state facilities, it is critical to utilize only those products which are capable of doing the job for which they are intended. Failure of materials, regardless of cause, necessitates repair or replacement, often at considerable additional cost to the state.

Unfortunately, many roofing products and materials available today have not been on the market long enough for their long-term performance to be known. Usually this roofing performance information is generated slowly with the passage of time. Additional time is then required to record and analyze the performance data. In order to more quickly establish roofing performance histories and make the information readily available, ORMSC decided to create a computer-based data base (ROOFDATA).

The combination of roofing design experience, construction supervision responsibilities, and a large repeat client base affords the Design and Construction Group with the unique opportunity to synthesize information derived from diverse sources. Data established through the monitoring of critical materials used in the construction of the roofs of state buildings adds to available resources which can be drawn upon and used in evaluating materials and systems performance. When properly utilized ROOFDATA has the dual benefit of speeding production while improving quality.

The development of ROOFDATA has been an evolutionary process. Initially paper records on the performance of specific roofing projects were maintained. It was felt that information provided by these records offered the potential to save New York state money on future roof repairs and maintenance. It would also assist in building maintenance budgeting, with respect to more accurately anticipating roof replacements. It was subsequently determined that an electronic data base would be a much more interactive tool than paper records. A computer data base would allow for the recording and analysis of a far greater number of data elements.

With the assistance of computer staff from the Design and Construction Group's Office of Program Administration and Analysis, ORMSC roofing personnel developed the initial roofing performance data base. The data input screen for this system is illustrated in Figure 1.

Ours is a research approach triggered by actual roofing problems. Information about design, installation and performance is assembled and analyzed with the aid of the computer. The findings are made available to designers and specifiers in our organization in order to improve roofing design and performance. As with many computer research start-ups, a review and testing of the initial data base revealed shortcomings and needed improvements. Realization that the need for identifying project roofing failures occurs on both the "macro" and "micro" levels of analysis led to additional changes.

A review of general data base literature, and recent roof-

ing research in particular, was carried out. Much of the previous research was single-problem oriented and did not lend itself to our specific need for a wider multi-material and system performance approach.

Of the literature reviewed, the National Roofing Contractors Association's "Project Pinpoint"<sup>3</sup> was found valuable in stimulating our thoughts on data base elements and identification of problem projects. Although it would be desirable to use identical terms to take advantage of comparative data, we found that applied research for a specific organization's needs must be the final consideration in the research approach, selection of terms and data base elements. Some similarities of terms with "Project Pinpoint" can be found and some differences are obvious.

Analysis suggested that the data base needed expanded capabilities for identifying materials and systems failures on single roofed buildings, as well as multiple roofs on a single building, and multiple buildings within a single project. Thus, building number, roof number and number of roofs were added as data base elements.

In addition to providing the ability to identify variations in construction on different roofs on a single building or project, the new data base elements allow for the identification of similar roofing problems in individual or groups of buildings.

The continued application of need-specific identification led to additional data base elements which allow the recording of histories, observations and test data on existing materials and systems. These were included as elements to assist in the design process by maintaining a record of the conditions and problems necessitating removal or repair.

The number of desired data elements resulted in the development of two entry screens, EXISTING CONDITIONS-SCREEN #1 and NEW WORK-SCREEN #2. The NEW WORK-SCREEN #2 becomes our main research tool of the future. It contains information on generic materials and systems actually specified and installed. With the passage of time, the reporting and resolution of roof problems will be added.

## ROOFING PERFORMANCE DATA BASE

ROOFDATA runs on the Design and Construction Group's PRIME 6350 super minicomputer using PRIME PT 250 terminals with PRIME INFORMATION and PRIMOS operating system. This roofing data base will be integrated with a menu-driven, group-wide project data base system. Other computer services including word processing, electronic mail and graphics are available on the PRIME 6350.

Computer aided design and drafting (CADD) is used for most major projects. Its greatest value, however, is its use on projects derived from a prototypical design, or those which utilize easily modified standard details from the extensive library which has been developed. New and rehabilitation roofing projects lend themselves quite readily to the CADD system. This system runs on a PRIME 6550 super minicomputer.

The accumulated data (original field conditions, testing, design specifications, manufacturers and contract items) and life-cycle experiences in performance constitute the ongoing elements of our data base. The ROOFDATA data base field elements include:

- *Project Identification*—Project number, previous project number, project title, facility, county, state construction district number, cost estimate.
- *Roof Identification*—Building number, roof number, number of roofs, existing and new roof slopes, roof with tear-off, roof without tear-off, new construction, repair.
- *Construction Elements*—Existing and new; deck, vapor retarder, insulation, roof system, flashing, generic material, manufacturer.
- *Tests and Surveys*—Visual, asbestos-roofing and flashing, nuclear moisture meter.
- *Contract Identification*—Contract number, contractor, contract cost, construction completion date, warranty length, warranty expiration date.
- *Project and Contract Administration*—Record number, project chief, job captain, engineer-in-charge (field construction inspector).
- *Problem Identification and Resolutions*—Problem project, problem type, remarks.

The use of the data base field elements labeled "Roof System and Generic Material" need further clarification. The specific uses, abbreviations and standardized terminology for those field elements are shown in Table 1.

The data base structure reflects project design, contract and construction procedures. The early stages of the design or rehabilitation procedure usually includes a visit to the site or building to review existing conditions. Required testing, which may include testing for the presence of asbestos in existing roofing materials, nuclear meter testing for moisture within the existing roofing system, and a complete visual inspection are performed.

This preliminary information will be entered into the data base at the beginning of the project. The first information entered on an EXISTING CONDITIONS-SCREEN #1 are the record and project numbers (see Figure 2).

Fortunately, the Design and Construction Group data base management system is in a sophisticated state of development and use. Upon entry of the project number, many of the preliminary data elements which already exist in the system will be automatically copied to SCREEN #1. These items include previous project number, project chief, job captain, preliminary estimate, building number, project title, facility, county and district number.

The existing roof conditions found on the field trip will provide the remaining elements indicated on SCREEN #1. These include test results and special problems. As the new roofing system design develops and decisions are made, the new generic materials and roofing system will be entered on NEW WORK-SCREEN #2 (see Figure 3).

This procedure will continue through contract development and construction, providing additional data base elements. These elements include contract number, contract amount, manufacturer, completion date, warranty length and warranty expiration date.

The inclusion of the construction physical completion date, length of warranty and warranty expiration date will put all the future roof problems and failures in the perspective of a time frame governed by life-cycle performance. Knowledge of premature roof systems failures, within standard warranty times, will assist in identifying and eliminating generic materials or roofing systems giving poor

performance. Similarly, identifying failures beyond warranty expiration may help spotlight superior performance of materials or systems.

Using statewide building location data elements (counties and construction districts—SCREEN #2) in correlation with problem roofs should allow further refinement in identifying weather extremes (temperature, moisture, solar radiation, etc.) as a contributor to roof failures. It may also pinpoint variations in construction performance standards, techniques or methods used by different contractors for the same materials and roofing systems in various geographic areas across the state.

In a like manner, information found in other single or multiple data elements can be compared in order to correlate material and system performance with a diversity of contributory factors.

In later years, if problems develop, the individual roof or roofs involved will be noted. Problem identification, history and resolution will be entered and maintained under remarks. These will be sources for tracking materials and systems performance. Standardization in entry of roofing failure "keywords" is especially important with respect to the ability to call up and group similar roof problems for the purposes of analysis and study of systems performance.

The columns below list the "keywords" selected to be entered as the first element under remarks for identifying the type or cause of a roof's failure. Additional detailed information can be added after the "keyword" to suit the project specifics.

<i>Single Ply</i>	<i>Urethane Foam</i>
Seam Failure	Foam Delamination
Fastener Failure	Coating Delamination
Wet Insulation	Foam Splits
Shrinkage	Coating Splits
Embrittlement	Shrinkage
Wind Damage	Splits
Mechanical Damage	Embrittlement
Splitting	Mechanical Damage
Adhesive Failure	
Insulation Facer	<i>BUR</i>
Delamination	Blistering
Flashing Failure	Splitting
	Wet Insulation
<i>Modified Bitumen</i>	Slippage
Blistering	Surface Erosion
Wet Insulation	Delamination
Splitting	Ridging
Ridging	Flashing Failure
Surface Erosion	
Seam Failure	<i>Asphalt Shingles</i>
Flashing Failure	Wind Damage
	Fastener Failure
<i>Metal</i>	Embrittlement
Coating Failure	Surface Erosion
Buckling	Cupping
Fastener Failure	
Sealant Failure	<i>Neoprene Composition</i>
Clip Failure	Surface Erosion
Wind Damage	Cracking
	Blistering

**SUMMARY**

Long-term application of ROOFDATA may include its use in the development of an expert system for roofing design. In such a future system, ROOFDATA might become a problem-specific data base which, when combined with an interrogation protocol, inference engine and a domain-specific expert knowledge base, could form the required expert systems architecture. Since expert systems are still in the early stages of development, usage will depend on the creation of suitable software.

ROOFDATA provides an easily and quickly accessible electronic historic record of roofing installations. It is a research instrument and a source of information on the successes and failures of designs, and the effectiveness of materials and systems. ROOFDATA provides for the identification of roof problems and their resolution. Judicious use of this information will allow for the design of the optimal roofing system to suit building conditions.

A fully documented record of design and performance will become a significant source of roofing knowledge and research; a resource that may be of interest to other state governments and the worldwide roofing community.

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0	1	2	3	4	5	6	7	7
0	DES.U08		D&C PROJECT CONTROL SYSTEM			mm/dd/yy		0
Roofing Information								
Contract No. :	:1)		Contract Amount :			:D1)		:
Proj Title :	:D2)							:
Facility :	:D3)		District :			:D6)		:
Proj Chief :	:D4)		EIC :			:D7)		:
Job Capt :	:D5)		Contractor :			:D8)		:
Warranty No :	:2)		Compl Date :			:D9)		:
Existing Sqr Footage :	:3)		Manufacturer :			:9)		:
Existing Deck Cnst :	:4)		Roof System :			:10)		:
Existing Membrane :	:5)		Generic Matl :			:11)		:
Existing Asbestos :	:6)		Ponding :			:12)		:
Existing Insulation :	:7)		Nuclear Srvy :			:13)		:
Existing Vapor Seal :	:8)		Frch Project :			:14)		:
Remarks :	:15)							:
:	:16)							:
:	:17)							:
:	:18)							:
0	1	2	3	4	5	6	7	7
0	0		0			0		0

Figure 1

0	1	2	3	4	5	6	7	7
0	DES.U08		D&C PROJECT CONTROL SYSTEM			mm/dd/yy		0
EXISTING CONDITIONS-SCREEN #1								
Record No. :	:		Proj.Chief :			Bldg.No. :		:
Proj.No. :	:		Job Capt. :			Roof No. :		:
Prev.Proj.No. :	:		Estimate :			Dist.No. :		:
Contract No. :	:							:
Proj.Title :			County :					:
Facility :								:
No. of Roofs :	:		Exist.Asbestos			:		:
Exist.Slope :	:		Roof :			:		:
Exist.Sq.Ft. :	:		Flashing :			:		:
Exist.Deck :	:		Exist.Flashing :			:		:
Exist.Vapor Ret. :	:		Loc. : Matls :			:		:
Exist.Insulation :	:		Loc. : Matls :			:		:
Exist.Roofing Sys. :	:		Nuclear Survey :			:		:
Exist.Generic.Mat. :	:		Ponding :			:		:
Remarks :	:							:
:	:							:
23 :	:							:
0	1	2	3	4	5	6	7	7
0	0		0			0		0

Figure 2

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0-----1-----2-----3-----4-----5-----6-----7-----7
0-----0-----0-----0-----0-----0-----0-----9
0 DES.008          D&C PROJECT CONTROL SYSTEM          um/dd/yy 0
Roofing Information
NEW WORK-SCREEN #2
Record No. : : Proj.Chief: : Bldg.No.: :
Proj.No. : : Job Capt. : : Roof No.: :
5 Prev.Proj.No.: : Estimate : : Dist.No.: : 5
Contract No. : :
E.I.C. : :
Contractor: :
Proj.Title: :
10 Facility : : County: : 10
Roof w/Tear Off: : Roof wo/Tear Off: : New Const.: : Repair: :
No. of Roofs : : New Generic Mat'l : :
15 New Slope : : Manufacturer: : 15
New Sq.Ft. : : Contract Amount : :
New Deck: : : Completion Date : :
New Vapor Ret. : : Warranty Length : :
New Insulation : : Warranty Expir.Date: :
20 New Roofing System : : Problem Project : : 20
Remarks: :
: :
23-----1-----2-----3-----4-----5-----6-----7-----7
0-----0-----0-----0-----0-----0-----0-----9
    
```

Figure 3

Generic Material	Roof System
BUR	ASP/CT-Gravel, smooth protected
EPDM	Adhered, mech. att., ballast, protected
PVC	Mech. att., adhered
Hypalon	Mech. att., adhered
PIB	Adhered
Urethane Foam	Silicone, urethane
Metal	Preformed, shopformed
Mod. Bitumen	SBS/APP-Gravel, granular, coated, protected
Asphalt Shingles	Shingles
Neoprene Composition	Traffic bearing
PVC Blend	Mech. att., adhered
(Insert Generic Mat'l.)	Repair

Table 1