AN INVESTIGATION OF THE ROLE OF DIFFERENTIAL STRUCTURAL MOTION AS THE CAUSE OF FLASHING PROBLEMS

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In order for a roofing system to perform as intended, each element of the system must function properly. The building design, the construction details, the roofing specification, the roofing materials and application, and the roof inspection and maintenance practices must all be of appropriate quality. When one of these elements is deficient, problems can be expected to occur. When a problem occurs, finding the deficient element is often a difficult task.

This paper presents the results of an investigation of several single story retail buildings which were experiencing problems with wrinkling and tearing of the perimeter flashings at parapet walls. A detailed investigation of the buildings was undertaken to determine the cause of the flashing problem and the reason why the problem did not occur on all of the buildings of the same type. The investigating team included representatives from the retail company, the building design firm, the roofing manufacturer, the roofing contractor, and an independent structural engineer. The results demonstrated conclusively that the problem was due to differential structural motion at the junction of the deck and walls. Visual observations from all inspected roofs and measurements from one instrumented roof, taken over a one year period, are presented.

KEYWORDS

BUR, contracting roof, differential motion, flashings, field data, in-situ measurements, roof, roofing.

INTRODUCTION

During late 1988 and early 1989, a small fraction of a national retailer's roofs were experiencing problems with wrinkling and/or tearing of base flashings near the corners of the buildings with raised parapet walls. A typical example is shown in Figure 1, with the wrinkles highlighted with white chalk. The roof membranes were of standard construction, three plies of premium glass built-up roofing (BUR), without gravel over fibrous glass roof insulation. All of the buildings had steel decks and concrete block walls. Approximately 10 to 15 percent of their newly constructed buildings were experiencing the problems. The retailer had recently changed engineering firms for their building designs, and the problems were much more frequent on the new larger stores, which were designed by the new engineering firm. The owner of the engineering firm had inspected the roofs and reported that the problems were due to contraction of the fibrous glass BUR membrane.

The potential cost of resolving the problem was sufficient to draw the attention of all involved parties. Although the problems were occurring on only a small fraction of the retailer's roofs, a significant number of roofs were involved, since the retailer had a large number of roofs. The proposed repair procedure was to install a curb around the perimeter of the roof, securely attached to the deck. The flashing would then be attached to the deck and the curb, with a counter-flashing from the parapet walls over the curbs. The cost of the repairs was estimated to be over $20,000 per roof, resulting in total cost in excess of $1 million for all of the roofs. In addition, unless there was an understanding of the problem, there was no assurance that any repairs would be permanent. Finally, it was necessary to identify the deficient element of the roofing or structural system in order to appropriately allocate the repair costs.

Initial inspections of the retailer's buildings by the roofing manufacturer's field technical service representatives found no evidence to support a conclusion that the roofing materials were at fault. The retailer was informed the manufacturer had found the problems were not caused by the roofing materials or installation, and the manufacturer had no responsibility to make repairs. The retailer's personnel did not accept this evaluation; they were convinced the roofing materials were at fault.

Considering the magnitude of the potential liability and the valued relationship of a long-term customer, the manufacturer placed a high priority on resolving this issue. A project team was formed including representatives from the roofing manufacturer's technical, marketing and field technical service organizations, as well as an independent structural engineering consultant. The engineering consultant was familiar with the design of single-story retail buildings of the type constructed by the retailer. The goal of the team was to clearly identify the source of the problem to the satisfaction of all involved parties.

The problem investigation had two major parts; inspection of several problem roofs, and inspection and instrumentation of one typical roof. The manufacturer's project team, together with a team from the retailer, jointly inspected four roofs. Technical representatives from the manufacturer prepared and installed the instrumentation on a fifth roof of the same design as the jointly inspected roofs. The fifth roof was also exhibiting the same flashing problems and was chosen for its proximity to the manufacturer's technical facilities. This paper documents the results of these efforts.

ROOF INSPECTIONS

Four roofs were inspected during the manufacturer/retailer joint inspection program; one in central Mississippi, one in central Louisiana, one in central Texas, and one in southern Missouri. A fifth roof, located in central Ohio, was inspected by representatives from both the retailer and the manufacturer, but at different times. This roof was of similar design to the Mississippi and Louisiana roofs and exhibited a similar pattern of flashing wrinkles as well. Each of these three were new larger stores completed in the fall of 1988. The Texas and Missouri roofs were older design stores and were both four or five years old. The Texas roof had no problems with wrinkled flashings, and the Missouri roof had the most severe wrinkling of all.

The buildings inspected were representative of the store types used by the retailer. The total roof area per building ranged from 650 to 1200 squares; the length of the front wall was between 200 and 400 feet. The larger roof areas were divided by an expansion joint which was parallel to the side walls. All of the stores were constructed with parapet walls on the sides and front of the buildings but not in the rear. Each roof was sloped ¼ inch per foot toward the rear of the building. All of the buildings were used as retail stores, and all had suspended ceilings with a dead-air plenum. In referencing directions, right and left are understood from the perspective of standing on the roof and looking toward the front of the store.

During the joint manufacturer/retailer roof inspections, the following observations were made. Unless a specific roof is mentioned, the observations apply to all of the roofs.

- There were no roof leaks reported on any of the roofs inspected.
- On all roofs, the field of the roof was generally in excellent condition.
- All flashings were modified bitumen membranes.
- All buildings had steel decks and concrete block walls.
- The flashing wrinkles appeared soon after construction of the buildings. The wrinkles were present on the roofs constructed in the fall of 1988 by the spring of 1989.
- The flashing wrinkles occurred primarily on the front wall near the side walls. The wrinkling is worst at the front corners and diminishes toward the center of the building. There are no wrinkles at distances greater than 30 to 60 feet from the corners, depending on the roof. There is little or no wrinkling of the side wall flashings. If present, it is much less pronounced than that of the front wall.
- There were no flashing wrinkles at the rear of the buildings or at expansion joints, except for the Missouri roof. The right side wall flashing of the Missouri roof was wrinkled within 25 feet of the rear corner.
- On the front walls, the directions of the flashing wrinkles form diagonals with lower end toward the center of the building and upper end toward the outer walls (see Figure 1).
- Where cuts were taken at wrinkled flashings at the front wall, it always revealed the cant strip was well adhered to the wood nailer on the deck, but was no longer adhered to the vertical parapet wall surface.
- At the problem areas, when the flashing was tightly adhered to the cant strips, the flashing showed a developing crack at the top of the cant. When the flashings were loose, the wrinkling was more pronounced.
- Where cuts were taken, it revealed differential motion had occurred between the cant strips and the walls, indicating there was relative motion between the wall and steel deck. The prevalent motion was along the front wall and away from the side walls, as much as .25 to .5 inch.
- Where cuts were taken, it revealed that the wood nailers and roof insulation boards were well adhered to the deck.
- The Texas roof had no problems with wrinkled flashings. The structural details of this building are different from the Ohio store. There is an extra support beam on the side walls, and the truss ends were fully grouted into the front wall. The deck welds are very prevalent.
- The Missouri roof had the worst wrinkling, and only this roof had wrinkled side wall flashing near a rear corner.
- Where cuts were taken, it revealed cant strips had moved from the side wall more than .5 inch. There was also evidence support steel had moved from the wall, perhaps as much as ⅞ of an inch. At the front wall corners, there was significant brick/block cracking and displacement.
- The Missouri store had polystyrene ceiling tile with fibrous glass batts laid on top as insulation back-loading. This was the only store with insulation back-loading on the suspended ceiling. This ceiling system would create larger plenum temperature differences than the other stores.
- The Louisiana store had an addition on the right side of the building. This formed two reentrant corners on the roof, but the flashings were not wrinkled at these corners.
- The Louisiana and Mississippi roof membranes were aluminum coated.

INSTRUMENTED ROOF

Roof Specifics

This roof was typical of the construction used on the other inspected buildings. The flashing wrinkles appeared over the first winter season, and were present during the inspection even though the temperature was well below freezing. The following additional specific observations were made.

- The front wall flashings were wrinkled near the right and left corners, as was typical of the other roofs. The right side was worse than the left. The right side of the building is not obstructed; the left side abuts a strip of stores. The front of the stores faces west.
- The roof trusses are resting on plates on the front wall but are not grouted into place.
- Along the front wall, for at least 36 feet from the right side corner, the steel deck sections that were adjacent to the front wall were no longer attached to the joists. The

welds between the deck and joists had been sheared from the front wall to the first line of bridging. Also, the joists had all moved to the north and were visibly deflected from the wall to the first line of bridging.

- The deck sections could be easily lifted by hand from the under side. Broken deck/truss welds were visible, and the deck had clearly moved on the trusses at some point (see Figure 2).
- The suspended ceiling is ¾ inch fibrous glass with no back-loading (see Figure 3).

Instrumentation

On May 11, 1989, temperature and motion measuring devices were installed in one of the retailer's stores in central Ohio. All sensors were connected to a data logger, which contained the electronics necessary to convert the voltage inputs to standard units. It contained sufficient memory to store the collected data until accessed by a second computer (see Figure 4). In addition to the motion and temperature inputs, the power supply voltage for the motion sensors was also recorded to determine if any changes were due to power supply drift. Over the year of hourly data collection, the supply voltage did not deviate more than one percent from its nominal voltage. Data was collected and stored once per hour.

The motion sensors were mounted to detect and record any relative motion between the steel roof deck and the building's outside walls. Two linear variable differential transformers (LVDTs) with a range of ±2 inches and guaranteed linearity were used. The bodies of both sensors were attached to a rigid support structure which was attached to the underside of the steel deck near the northwest corner of the building, which was the location of the most severe flashing wrinkling. The core of one LVDT was attached to a support which was cemented to the inner surface of the west (front) wall approximately 18 inches below the deck and 12 inches from the north wall. This sensor measures the relative motion between the roof deck and the west wall in the north/south direction. The core of the second LVDT was mounted on the north wall approximately 18 inches below the deck and 12 inches from the west wall. The second sensor measures relative motion between the roof deck and the north wall in the east/west direction. The sign of the displacement transducer data reported in this paper was chosen so that a positive change in the transducer output indicates motion of the steel deck toward the wall and a negative change in the output indicates deck motion away from the wall in each case. The LVDTs and the mounting supports are shown in Figures 5 and 6.

Four type T thermocouples were installed to measure the plenum air temperature, the inside west wall surface temperature, the outside west wall surface temperature and the outside ambient air temperature. The inside plenum air temperature was taken at a point approximately 5 feet from both the north and west walls and 18 inches below the steel deck. The interior west wall surface temperature was taken approximately 16 inches from the north wall and 4 feet below the deck. The exterior west wall surface temperature was taken approximately 20 inches from the building corner and 11 inches below the top of the wall on the outside perimeter of the building. At this point, the height of the parapet wall is greater than 11 inches so that the inside surface of the wall opposite the thermocouple is above the roof surface. The outside ambient air temperature was taken approximately 3/4 inch out from the outer perimeter facing of the north wall, 35 inches from the front corner and 11 inches below the top of the wall. The ambient air thermocouple was not shielded from the wind or rain in any way, but was placed so that it was generally shaded by the wall, except for times near sunrise or near sunset.

RESULTS

Data from the central Ohio roof was collected from the evening of May 11, 1989 through the morning of May 21, 1990. Two periods of data were lost; one was from September 12 to December 21, 1989, and the other from January 11 to February 16, 1990. The first loss occurred when a power surge blew the power fuse to the data logger. Even though the data logger had a battery back-up, with the fuse blown it did not have sufficient reserve power to continue operation and preserve the data until the data was collected months later. The exact cause of the second loss was not determined, but apparently an electrical surge or glitch wiped the logging program from the data logger memory. Since the data was gathered at a remote site, trips to the site to collect the data were taken at time intervals of one to three months, as schedules permitted. For future studies, it is recommended that the periodic data collection trips be more frequent or that provision be made to access the data and check the condition of the data logger remotely. In this way, lost data can be minimized.

The data from the instrumented roof is summarized in Tables 1 through 4.

Table 1 presents a summary of the three most significant temperatures; the plenum air, the outside west wall surface temperature and the outside air temperature. To simplify the tables and some graphs, the inside west wall surface temperature has been omitted in some cases. The inner surface temperature generally followed the plenum temperature and correlated least to the wall motions. In some cases, its inclusion would have added no additional insights and would have reduced the clarity of the data presented.

Tables 2 through 4 present correlation data. Table 2 gives the correlation of the front and side wall motions to the three significant temperatures on an hourly basis. Note the best correlations are to the plenum air temperature for either wall and the front wall had generally higher correlations than the side wall. Also notice the side wall correlations were very low in May and June of 1989 and much better thereafter. Tables 3 and 4 give two sets of correlations for both the front and side wall motions, respectively. The maximum daily motions occurring in a given month are correlated to the maximum daily temperature changes in that month, and the average daily motions are correlated to the average daily temperature on a monthly basis. The data trends in the second two tables, Tables 3 and 4, agree with the trends in the hourly data, Table 2.

Figures 7 through 10 present weekly averages of motion and temperature data for the year of data collection, with the periods of missing data indicated on the graphs. The complete set of weekly average temperatures are given in Figure 7.

In Figure 8, the weekly average of the position of the roof deck relative to the front and side walls is given; the plenum and outside air temperatures are given for reference. It is clear that a significant, permanent change of approximately −0.15 inch occurred in the deck position relative to the side wall during June 1989. A permanent change of perhaps —0.05 inch occurred in the position relative to the front wall. The sign of these changes indicates the walls have "outgrown" the deck by the indicated amount. However, the fluctuating changes that are seen on a weekly basis are normally larger than the permanent ones.

Figures 9 and 10 compare the maximum motions during each week to the cumulative annual motion to date relative to the front and side walls, respectively. The plenum temperature is included for reference. Notice that the weekly fluctuations are significantly larger than the cumulative ones, except for the one-time, large movement relative to the side wall mentioned previously and seen clearly in Figure 10.

Figures 11 through 14 show hourly temperature variations for 72-hour periods in four different seasons of the year. Figures 15 through 18 show the relation of motion relative to the front and side walls to the most significant hourly temperatures. Careful examination of these graphs, noticing the peak position of each curve, reveals the motions are most closely tied to the plenum temperature. This fact is substantiated by the correlations. A correlation to the other temperatures is also visible since each of the temperatures is correlated to the others. This, together with the direction of the relative motions with rising temperature, is key to identifying the mechanism driving the motion.

During the year of data collection the extremes of motions and temperatures were recorded. The motion relative to the front wall achieved a maximum of .384 inch during the year. The daily front wall motion averaged .113 inch for the year with a minimum of .012 inch and a maximum of .266 inch. The yearly maximum occurred at a time when both the cumulative and daily motions were large. The motions relative to the side wall were usually much less except for the period in June of 1989. The motion relative to the side wall achieved a maximum of .206 inch during the year, most of this occurring in June of 1989. The daily side wall motion averaged .022 inch for the year with a maximum of .165 inch and a minimum of .004 inch. Without the June 1989 data, the maximum side wall motions would have been much lower.

CONCLUSIONS

The inspections and the results from the instrumented roof provided a clear explanation of the source of the problem. The upper bond beam, a reinforcing structural element, in the front wall was apparently not discontinuous at the expansion joints, as it should have been. Subsequent thermal expansion of the beam sheared the deck/truss welds on the deck sections adjacent to the front wall. Once the welds were sheared, the deck was free to expand and contract as its temperature changed.

The independent structural engineer concluded, "Aside from the fact that the type of flashing used on these parapet walls is not conducive to the differential movement which is likely to occur among various structural components of any building, this particular flashing problem is the direct result of design and construction methods which have also resulted in structural failure of the deck-diaphragm in the vicinity of the front wall, and which could lead to even more serious problems if not corrected."

Further, there was ample evidence that directly refuted the hypothesis of a contracting roof membrane as the source of the problems. There were no signs of membrane/roof insulation movement away from the nailers or deck edge. There was no observation of patterned deflection of the roof insulation fastener screw shanks and no evidence of chipping of the paint on the underside of the deck at the screw penetrations. There were no membrane wrinkles in the field of the roofs, except at isolated locations related to rooftop equipment. There were no wrinkles at control joints and generally no wrinkles at the rear corners. A contracting membrane would have created wrinkles at all of these locations, rather than only the front corners. The roof insulation and membrane were functioning properly.

The deck temperature was identified as the most significant variable associated with the observed differential motions. As the deck and plenum temperatures rise, the deck expands and moves toward the outer walls. Although the actual deck surface temperature was not measured, in a dead air plenum the deck temperature is closely related to the plenum temperature. In any future studies, the deck temperature will be measured directly. The Missouri store experienced the most severe differential motions, and it was the only store with high levels of insulation at ceiling level. Since the plenum had no air circulation to the interior of the building, a dead air plenum, the temperature excursions of the Missouri store plenum were more extreme than stores with less ceiling level insulation. This caused the problems to be most severe with the Missouri roof.

Some specific conclusions regarding the instrumented Ohio roof are given below.

- There is continuous daily cyclic movement between the steel deck and the wall structure. The motion with respect to the front wall averaged .113 inch daily with maximum daily motion of .266 inch. The motion with respect to the side wall averaged .022 inch daily with a daily maximum of .165 inch.
- The average motion with respect to the front wall is much larger than the average motion with respect to the side wall. The decking runs parallel to the front wall. There was one large irreversible deck motion of .15 inch away from the front wall that occurred in June 1989.
- The total differential movement observed over the observation period is larger than the maximum daily movement by only a small amount. The total front wall differential motion during the year was .384 inch, and that of the side wall was .206 inch.
- The observed differential motion correlates most closely with the plenum air temperature.
- The proposed solution of adding curbs and counterflashings around the perimeter of the roof should work. The work could be postponed until the flashings develop leaks and are in need of repairs.

The problem was demonstrated conclusively to be caused by differential motion between the structural roof deck and the exterior building walls. The design of the buildings was found to be adequate, but the details of building construction were found to be inadequate on the buildings with roof problems. When the construction was as specified, there were no problems, but when the plans were not followed explicitly, bond beams not discontinuous at expansion joints as specified, the roof deck became inadequately anchored to the wall structure. This allowed the excess differential motion which caused the flashing problems. The results of the investigation convinced the retailer's representatives that the problem was structural and that the roofing materials had no part in the problem. In addition, the retailer decided that the manufacturer would receive an exclusive specification for all of their new construction. The work of the project team in producing factual data resulted in the proper identification of the actual problem cause and in the retention of a valued customer.

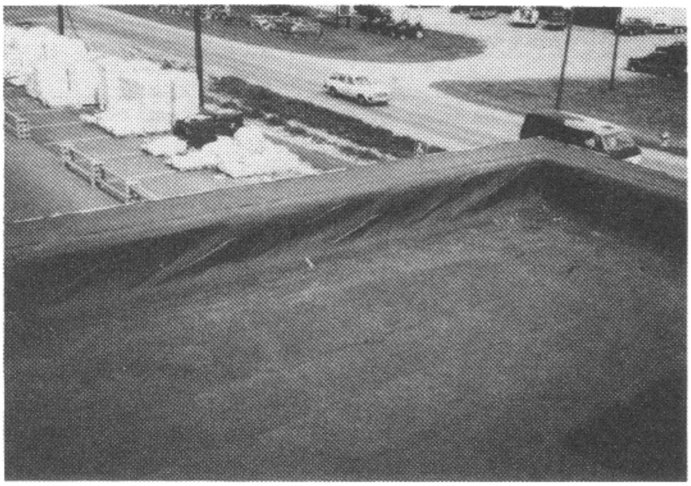

Figure 1 *Wrinkling and/or tearing of base flashings (wrinkles highlighted with white chalk).*

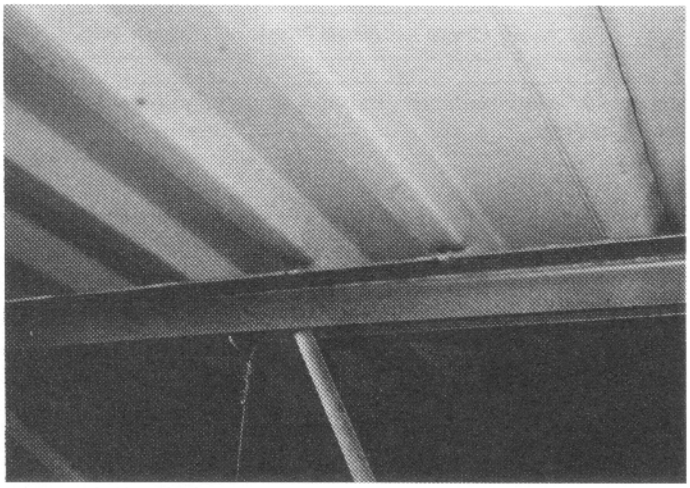

Figure 2 *Broken deck/truss welds and depicts deck movement on the trusses.*

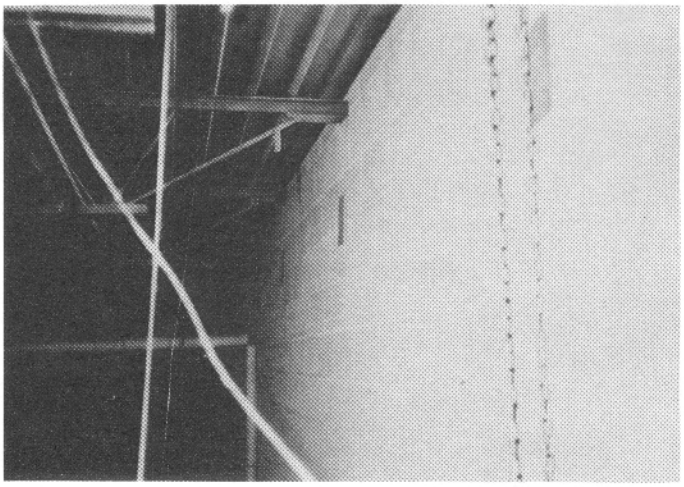

Figure 3 *Suspended ceiling is ¾ inch fibrous glass with no back-loading.*

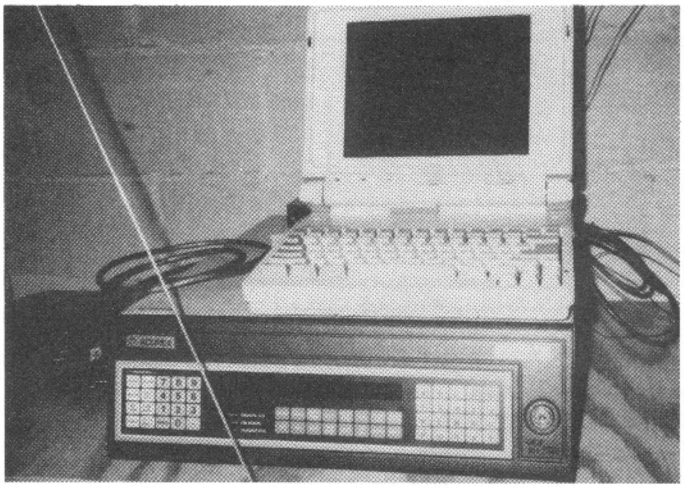

Figure 4 *Data logger.*

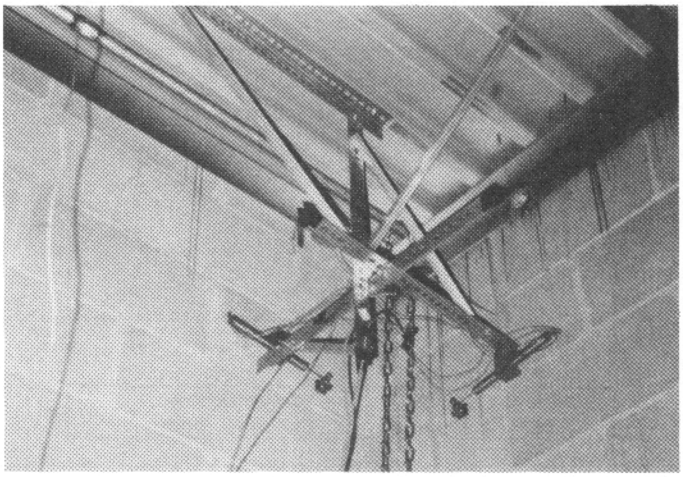

Figure 5 *LVDTs and mounting supports.*

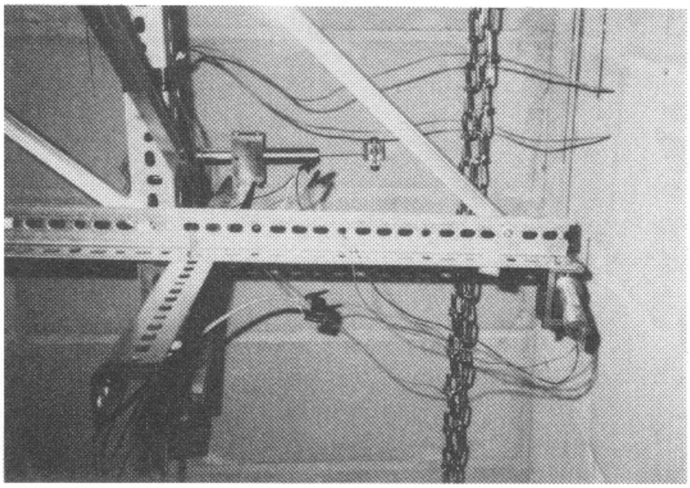

Figure 6 Detail of LVDTs and supports.

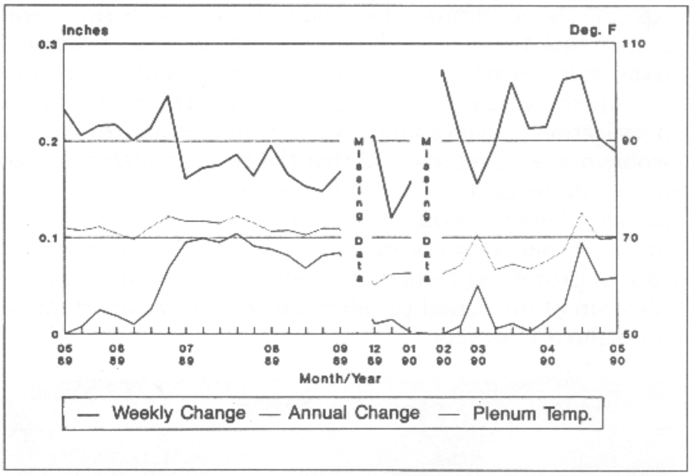

Figure 9 Maximum weekly and total annual front wall to deck motion weekly average.

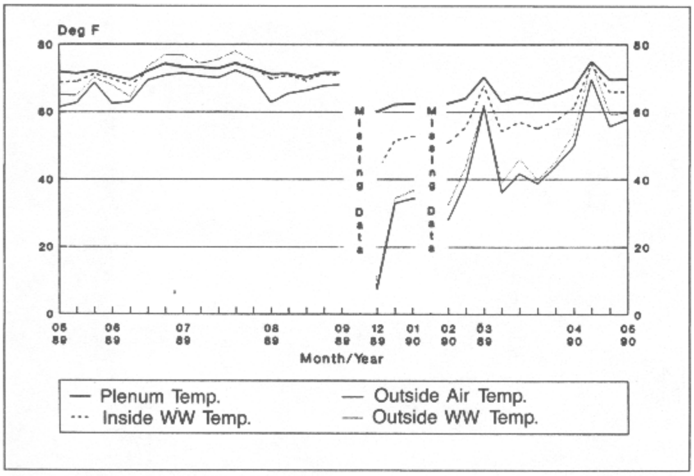

Figure 7 Outside air and plenum temperatures with west wall surface temperatures weekly average.

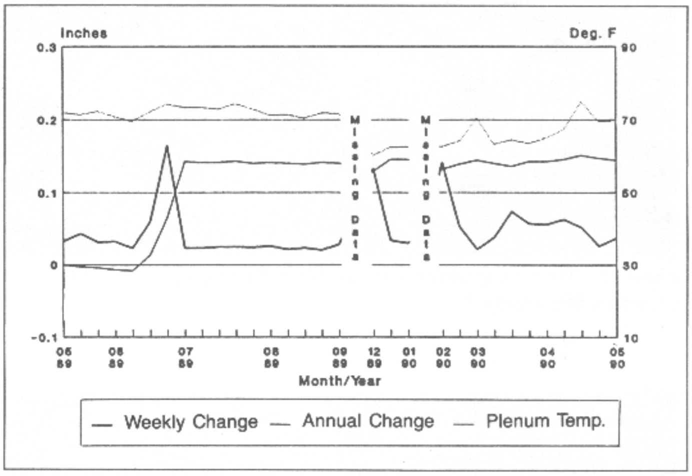

Figure 10 Maximum weekly and total annual side wall to deck motion weekly average.

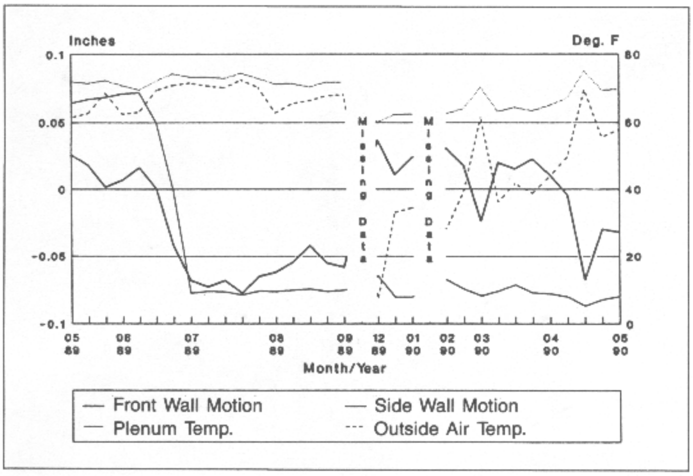

Figure 8 Front and side wall average positions with reference temperatures weekly average.

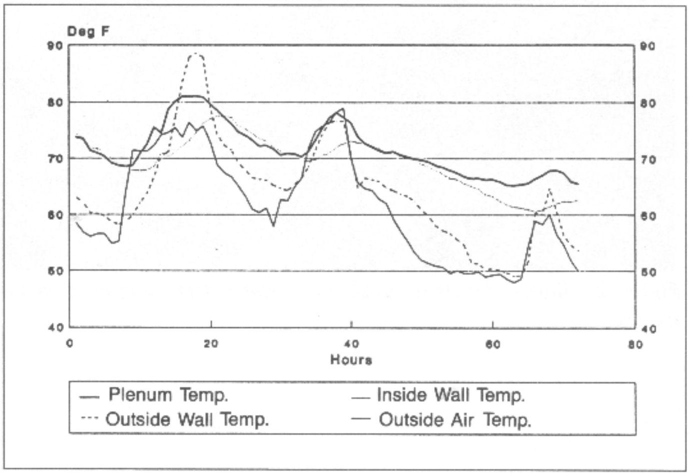

Figure 11 Typical temperature variation—Spring hourly data, 5/21/89-5/23/89.

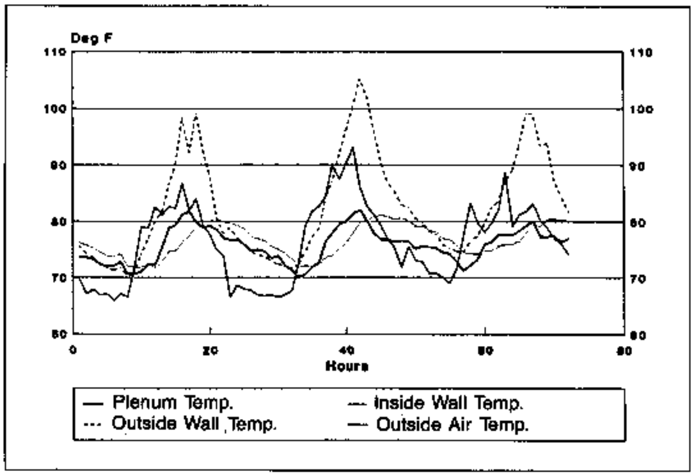

Figure 12 Typical temperature variation—Summer hourly data, 7/23/89-7/25/89.

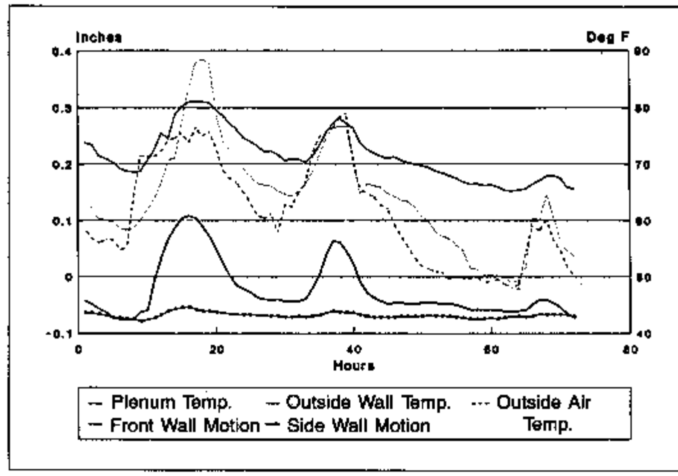

Figure 15 Wall motions and temperatures—Spring hourly data, 5/21/89-5/23/89.

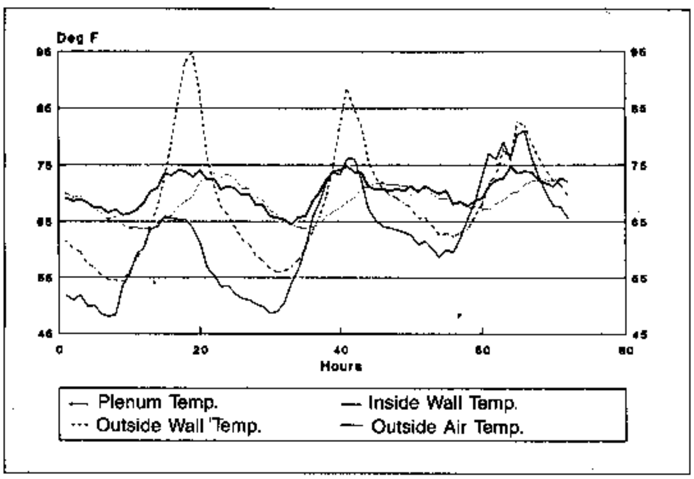

Figure 13 Typical temperature variation—Fall hourly data, 9/03/89-9/05/89.

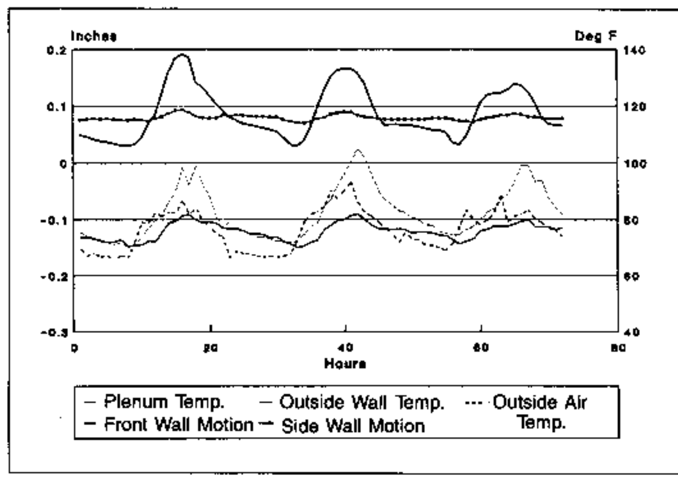

Figure 16 Wall motions and temperatures—Summer hourly data, 7/23/89-7/25/89.

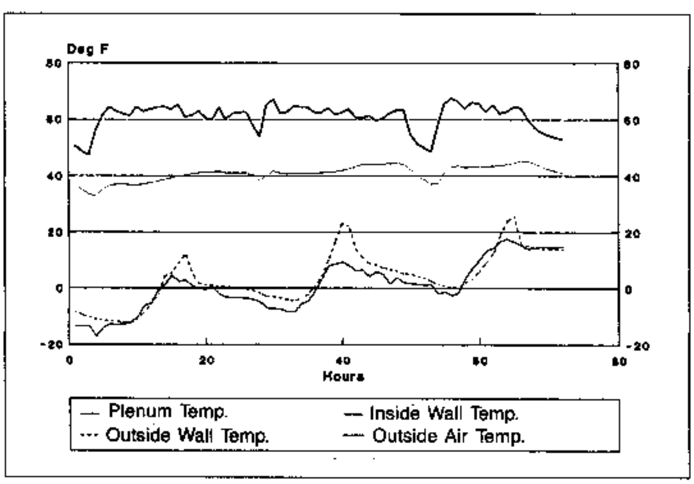

Figure 14 Typical temperature variation—Winter hourly data, 12/21/89-12/23/89.

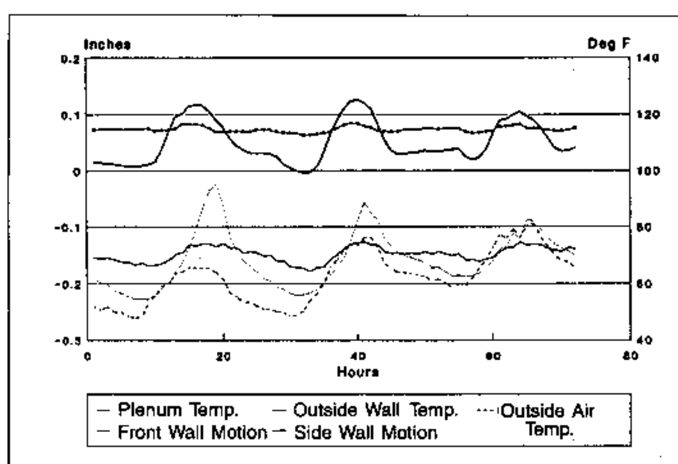

Figure 17 Wall motions and temperatures—Fall hourly data, 9/03/89-9/05/89.

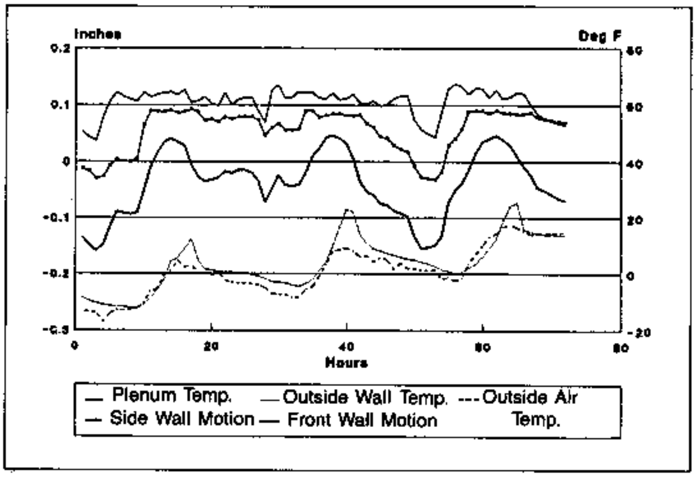

Figure 18 Wall motions and temperatures—Winter hourly data, 12/21/89-12/23/89.

		Average Daily Temperature deg F			Average Daily Temperature Change - deg F		
Date	**Number of Obs**	**Plenum Air**	**Outside W.Wall**	**Outside Air**	**Plenum Air**	**Outside W.Wall**	**Outside Air**
May 89	21	70.9	63.5	60.9	9.7	22.7	21.1
Jun 89	30	71.9	70.7	66.7	8.6	25.6	21.4
Jul 89	31	73.4	76.1	70.9	8.7	26.3	20.6
Aug 89	31	71.7	71.7	66.9	8.4	24.7	19.4
Sep 89	12	70.9	69.0	65.4	6.9	20.9	16.5
Dec 89	11	61.0	18.9	16.8	13.2	15.3	15.1
Jan 90	11	62.6	35.6	34.4	9.3	13.5	11.4
Feb 90	13	62.4	34.2	30.7	11.0	23.8	17.7
Mar 90	31	65.4	46.8	43.6	9.2	22.2	18.5
Apr 90	30	68.1	54.3	51.5	9.8	26.8	22.9
May 90	21	69.8	60.1	58.0	7.0	20.7	17.9

Table 1 Average daily temperatures and temperature changes by month.

		Front Wall Motion			Side Wall Motion		
Date	**Number of Obs**	**Plenum Air**	**Outside W.Wall**	**Outside Air**	**Plenum Air**	**Outside W.Wall**	**Outside Air**
May 89	485	0.86	0.81	0.80	0.20	0.01	0.01
Jun 89	721	0.83	0.78	0.72	0.33	0.37	0.18
Jul 89	744	0.85	0.79	0.77	0.80	0.62	0.42
Aug 89	745	0.84	0.77	0.75	0.78	0.62	0.48
Sep 89	275	0.79	0.80	0.77	0.64	0.43	0.52
Dec 89	249	0.80	0.42	0.39	0.54	0.47	0.47
Jan 90	252	0.86	0.44	0.50	0.89	0.25	0.32
Feb 90	299	0.89	0.50	0.48	0.69	0.38	0.42
Mar 90	743	0.88	0.69	0.67	0.70	0.48	0.48
Apr 90	718	0.91	0.81	0.82	0.77	0.62	0.63
May 90	491	0.87	0.79	0.78	0.53	0.39	0.43

Table 2 Correlation of hourly wall motions to temperature by month.

	Maximum Daily Motion to Maximum Daily Temp Changes			Average Daily Motion to Average Daily Temperature		
Month, Year	**Plenum Air**	**Outside W.Wall**	**Outside Air**	**Plenum Air**	**Outside W.Wall**	**Outside Air**
May 89	0.93	0.87	0.85	0.86	0.90	0.87
Jun 89	0.92	0.83	0.57	0.80	0.80	0.60
Jul 89	0.92	0.85	0.65	0.93	0.85	0.70
Aug 89	0.98	0.84	0.81	0.89	0.74	0.49
Sep 89	0.92	0.88	0.92	0.90	0.94	0.76
Dec 89	0.87	0.80	0.89	0.84	0.59	0.53
Jan 90	0.83	0.70	0.27	0.78	0.34	0.48
Feb 90	0.86	0.76	0.13	0.94	0.86	0.84
Mar 90	0.97	0.83	0.58	0.98	0.94	0.93
Apr 90	0.96	0.83	0.68	0.98	0.95	0.92
May 90	0.94	0.86	0.81	0.89	0.83	0.78

Table 3 Correlation of daily front wall motion to temperature by month.

	Maximum Daily Motion to Maximum Daily Temp Changes			Average Daily Motion to Average Daily Temperature		
Month, Year	**Plenum Air**	**Outside W.Wall**	**Outside Air**	**Plenum Air**	**Outside W.Wall**	**Outside Air**
May 89	0.84	0.60	0.60	0.45	0.58	0.62
Jun 89	0.34	0.46	0.07	0.33	0.43	0.15
Jul 89	0.91	0.83	0.59	0.76	0.76	0.55
Aug 89	0.85	0.71	0.62	0.77	0.62	0.30
Sep 89	0.94	0.73	0.89	0.57	0.44	0.47
Dec 89	0.67	0.84	0.79	0.41	0.76	0.75
Jan 90	0.98	0.51	0.17	0.50	0.02	0.27
Feb 90	0.85	0.58	0.07	0.45	0.59	0.64
Mar 90	0.90	0.74	0.46	0.65	0.59	0.63
Apr 90	0.92	0.68	0.45	0.85	0.80	0.79
May 90	0.67	0.61	0.54	0.42	0.27	0.19

Table 4 Correlation of daily side wall motion to temperature by month.