



UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

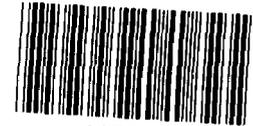
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PROCUREMENT, LOGISTICS,
AND READINESS DIVISION

B-206021

FEBRUARY 22, 1982

The Honorable John G. Fary
Chairman, Subcommittee on Public
Buildings and Grounds
Committee on Public Works and
Transportation
House of Representatives



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Dear Mr. Chairman:

Subject: Foundation Problems Encountered During
Construction of the Federal Office
Building and Courthouse in Springfield,
Massachusetts (PLRD-82-39)

In response to your June 18, 1981, letter, we have reviewed the foundation problems encountered during the construction of the Federal office building and courthouse in Springfield, Massachusetts. You specifically asked about increased cost implications as well as where the problem originated--the contractor, the architect-engineer, or the General Services Administration (GSA).

During our review, we examined documents at GSA's central office in Washington, D.C., and its regional office in Boston, Massachusetts, and the construction site relating to geotechnical studies, building design, construction contracting, and foundation construction problems. We interviewed various contractor and architect-engineer representatives and regional and central office officials of GSA. In addition, we visited the construction site in Springfield, Massachusetts, to observe the foundation problems, corrective actions underway, and progress of the construction work.

The results of our review are discussed in detail in the enclosure. In summary, we found that during the sheet piling extraction operations, cracks developed in parts of the foundation wall and in the upper floor slabs of the building and the foundation settled from 1 to 4 inches.

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All parties--the phase I contractor, the architect-engineer, the geotechnical engineer, and GSA--agreed that the foundation settlement problem resulted from the use of a vibratory hammer to extract sheet piling after most of the phase I construction work was completed. GSA believes that the phase I construction contractor should correct the foundation problem and pay expenses incurred. The contractor is correcting the work but will submit a claim for costs incurred. The contractor told GSA that the natural condition of the soil contributed to the foundation settlement problem. The architect-engineer also advised GSA that he expects to be reimbursed for all effort expended in connection with the settlement problem.

The amount of potential claims and extra costs, if any, that will be incurred by the Government is not known at this time.

As discussed with your Office, this report does not contain any conclusions or recommendations concerning the validity of the potential claims. Any attempt at this point to evaluate the claims would be a speculative matter, and we do not wish to prejudice the Government's case in any actions that might come before the GSA Board of Contract Appeals.

We provided GSA regional officials with a copy of the enclosure and asked for their oral comments. They agreed with the facts presented in the enclosure.

We are sending copies of this report to the Administrator of General Services, the architect-engineer, the phase I contractor, and other interested parties upon request.

Sincerely yours,



Donald J. Horan
Director

Enclosure

FOUNDATION PROBLEMS ENCOUNTEREDDURING CONSTRUCTIONOF THE FEDERAL OFFICE BUILDING ANDCOURTHOUSE IN SPRINGFIELD, MASSACHUSETTSBACKGROUND

In 1977 the Congress authorized the construction of a Federal office building and courthouse in Springfield, Massachusetts, at an estimated project cost of \$14,783,000. This amount was appropriated in March 1978 by Public Law 95-240. On March 27, 1979, the General Services Administration (GSA) awarded a design contract for the project. It later advertised and awarded to the lowest responsible bidders two fixed-price contracts for the phased construction of the building, as shown below.

<u>Phase</u>	<u>Contractor</u>	<u>Date of award</u>	<u>Contract amount</u>	<u>Construction schedule</u>	
				<u>Start</u>	<u>Completion</u>
I	Roncari Industries, Inc. East Granby, Conn.	9/5/80	\$3,170,000	10/3/80	6/21/81
II	Daniel O'Connell's Sons, Inc. Holyoke, Mass.	4/3/81	\$7,780,435	6/26/81	8/3/82

The phase I contract covers the excavation, foundation, concrete work, and structural steel framing of the building. The phase II contract provides for the completion of the interior and exterior of the building, including the plumbing, heating, ventilation, air-conditioning, elevators, and electrical and security systems. On completion of phases I and II, a third phase will be awarded to complete the building construction, which includes landscaping, carpeting, interior painting, and other minor work. When completed, the five-story building will provide about 60,000 square feet of occupiable area for use by various Federal agencies, including the United States District Court and the Department of the Treasury. The first floor will be leased space for commercial interests..

GSA's central office released \$14,768,000 of the appropriated funds for the building construction and withheld \$15,000 for central office support. As of September 30, 1981, GSA had obligated \$14,117,720 of the building construction funds, leaving an unobligated balance of \$650,280, as shown on the following page.

	<u>Building construction fund</u>		
	<u>Budgeted</u>	<u>Obligated</u>	<u>Unobligated</u>
Site acquisition	\$ 1,353,000	\$ 1,351,338	\$ 1,662
Design	1,100,000	1,426,155	-326,155
Construction	11,765,000	11,135,227	629,773
Management and inspection	<u>550,000</u>	<u>205,000</u>	<u>345,000</u>
Total	<u>\$14,768,000</u>	<u>\$14,117,720</u>	<u>\$650,280</u>

The Public Buildings Service Region 1 Assistant Regional Administrator stated that GSA will not know if additional funding will be required to complete the building until phase I work has been completed. As discussed later, GSA has not estimated the cost implications of correcting the settlement problems and the amount needed to settle potential claims.

IMPORTANCE OF GEOTECHNICAL EXPERTISE

Problems during site excavation and foundation construction for Federal buildings have troubled GSA since the early 1960s. In 1967 we reported that 15 of 28 Federal buildings, costing over \$2 million each, had such problems. Upon our recommendation, GSA hired a geotechnical engineer (soil and foundation expert), but the position was abolished a year later when GSA reorganized. In 1978 we reported (LCD-78-334, Sept. 19, 1978) that GSA paid extra costs caused by foundation construction problems. We again recommended that GSA (1) require staff geotechnical experts to participate in foundation construction inspections and (2) evaluate ways to obtain geotechnical expertise at the regional level.

GSA did hire an engineer with geotechnical expertise who worked at GSA's central office from July 1978 to June 1979 when he resigned. GSA hired another engineer with geotechnical expertise in January 1980. Because of the limited construction programs in recent years, GSA did not hire geotechnical experts for its regional offices. GSA decided to require design contractors designing buildings to have geotechnical capability, and the design contractor did obtain such services during the design of the Springfield building.

BUILDING DESIGN

On March 27, 1979, GSA awarded a building design contract to a joint venture of Cannon Design, Inc.; the Ehrenkrantz

Group; and Desmond & Lord, Inc. The contract, as amended, calls for all preliminary investigations, engineering, design, and other professional services necessary in preparing a predesign program directive. The contract also provides for final working drawings, specifications, a detailed cost breakdown estimate, and construction inspection services, including the services of a geotechnical engineer. The estimated contract price, as amended, is \$1,129,309.

Pursuant to the contract, a geotechnical engineer, Goldberg-Zoino & Associates, Inc. (GZA), Chicopee, Massachusetts, was hired to perform a subsurface investigation and geotechnical engineering study of the construction site. The purpose and scope of the study was to

- interpret and evaluate the subsurface conditions,
- verify the preliminary foundation concept selected by the design contractor,
- present the results of geotechnical tests and stability analyses regarding settlement and performance under earthquake loading, and
- provide geotechnical criteria for structural design and construction implementation of the recommended foundation scheme.

In May 1980 GZA completed its study which included the results of 10 test borings and 1 pilot boring taken in May 1978 as part of the preliminary investigations of the site selection. The study supported the selection of the proposed structure: a 12-foot deep basement, continuous spread footings in natural granular soils to support exterior columns and wall loads, and individual spread footing foundations in natural granular soils to support interior columns. The study also indicated that Bridge and Worthington Streets and most of Main Street at the site would require a sheeted excavation consisting of either a braced support system or a cantilevered support system to protect the streets and utilities from damage due to soil movements.

CONSTRUCTION PROBLEMS ENCOUNTERED DURING PHASE I CONSTRUCTION

On August 7, 1980, GSA received six bids for the phase I construction. After evaluating the bids, GSA awarded the contract on September 5, 1980, to Roncari Industries, Inc., which submitted the lowest bid. On October 3, 1980, GSA issued a notice to proceed to the contractor.

GSA provided the contractor with specifications which contained the results of the 11 borings and notification that the GZA May 1980 geotechnical study was available for review in the design contractor's office. Carter Pile Driving, Inc., hired by the phase I contractor to place the sheet piling for the excavation, initially submitted a proposal for a braced support system to the design contractor, which was approved. The braced support system is comprised of sheet piling driven into the ground and laterally supported above ground by steel beams.

Following this, Carter submitted a proposal for a cantilevered support system which was reviewed by GZA and approved by the design contractor. The cantilevered support system is comprised of sheet piling driven deeper into the ground so that the imbedded sheeting could resist the lateral earth pressure above the bottom of the excavation, and does not require steel beams above ground. The cantilevered support system required the sheet piling to be driven to a maximum depth of 32 feet into the ground from an elevation of 6 feet below street level instead of the 24-foot depth that would have been required with the braced support system. According to GSA, it was easier for the contractor to do excavation work when the cantilevered support was used because no support beams were in the way. Since the cantilevered support system was cheaper than the braced support system, the Government is entitled to a credit, but GSA and the phase I contractor have not reached agreement on the amount of the credit.

On November 5, 1980, Carter began to drive the sheeting along the Worthington Street side of the building site. Carter initially drove the sheeting 32 feet into the ground using a Foster 40E electric vibratory hammer to drive the first 15 feet and then a diesel impact hammer to drive the remaining 17 feet. Because of the sloping grade, Carter eventually had to drive some of the sheeting only 15 to 20 feet into the ground, using a Foster 40E electric vibratory hammer first and, when necessary, the diesel impact hammer. After the sheeting was placed along Worthington Street, the operation moved to the Main Street side of the site.

Along Main Street, Carter initially drove the sheeting 32 feet into the ground using the Foster 40E electric vibratory hammer for the first 15 feet and the diesel impact hammer for the remaining distance. However, Carter was requested by the phase I contractor to accelerate the sheeting operation, and on December 5, 1980, Carter stopped using the Foster 40E electric vibratory hammer and switched to a more powerful MKT V-16 vibratory hammer. Carter

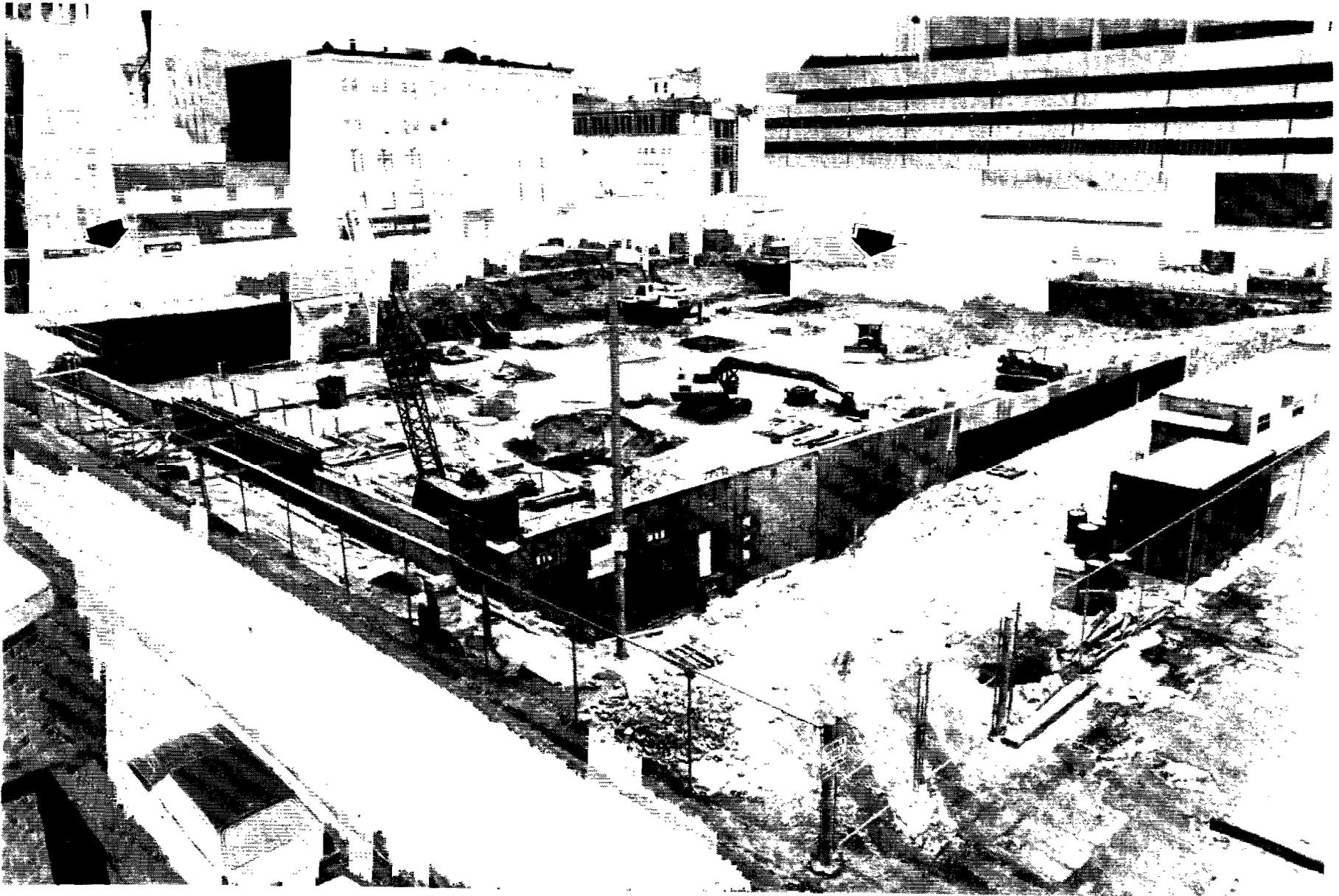
was able to drive the sheeting to a depth of about 25 feet with the MKT V-16 vibratory hammer and then, when necessary, used the diesel impact hammer. Depending on the grade of the slope, Carter had to drive some of the sheeting only 25 feet into the ground. About two-thirds of the sheeting along Main Street was driven with the Foster 40E electric vibratory hammer and diesel impact hammer, and the other one-third was driven with the MKT V-16 vibratory hammer and diesel impact hammer.

At the Bridge Street side of the site, all sheeting was driven with the MKT V-16 vibratory hammer and diesel impact hammer, initially to a depth of 32 feet and then gradually to a depth between 15 and 20 feet, depending on the grade of the slope. The driving of all sheeting was completed on December 19, 1980.

After most of the phase I work had been completed (May 1981), the following events occurred:

- May 20, 1981. Carter started to extract the sheeting along Main Street using the MKT V-16 vibratory hammer.
- May 27, 1981. Diagonal cracks developed in ground floor slabs, foundation walls, and slabs on grade at the corner of Main and Worthington Streets. Carter moved the extraction operation to the Bridge Street side of the site.
- June 3, 1981. Carter completed the extraction of the sheeting along Bridge Street. No difficulty was noticed in removing the sheeting and no cracks appeared on concrete walls or slabs.
- June 4, 1981. Carter began extracting the sheeting along Worthington Street. Cracks were noted on foundation walls.
- June 5, 1981. The phase I contractor ordered the sheeting extraction stopped.
- June 9, 1981. Sheeting extraction was resumed. A severe crack developed in the slab on grade and cracks also developed in the foundation wall and in the upper floor slabs. Sheeting extraction was immediately stopped.
- June 10, 1981. A water main burst on Worthington Street, flooding the street and the excavation along the building site. Survey readings taken by the phase I contractor on a column near the building's perimeter wall along Worthington Street indicated foundation settlement ranging from 1 to 4 inches.

The following photographs show the sheeting in place, the phase I work near completion, and the cracks that developed during the extraction of the sheeting.



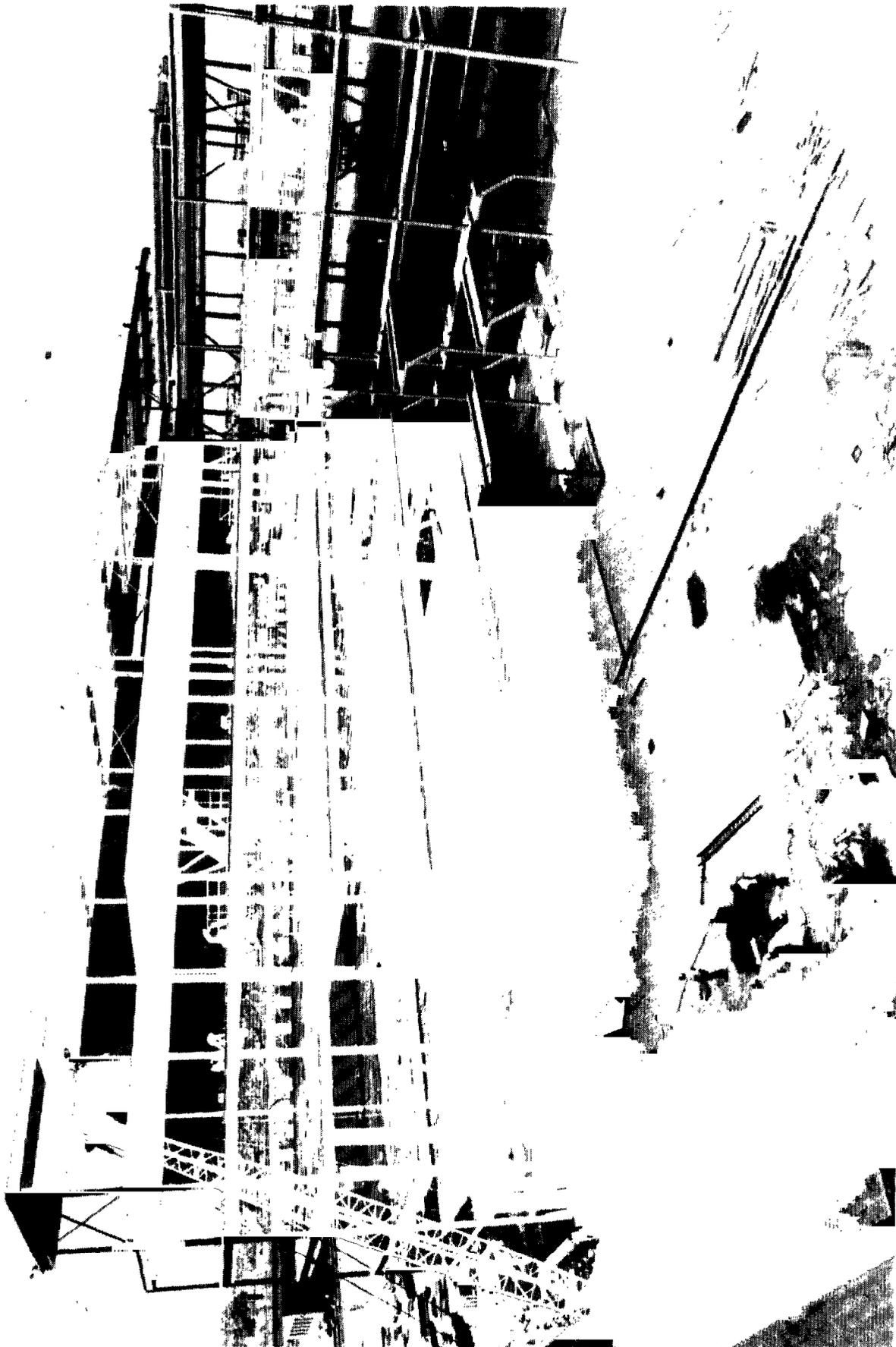
FEDERAL OFFICE BUILDING AND COURTHOUSE, SPRINGFIELD, MASS.
SHEETING ON MAIN AND BRIDGE STREETS AS OF JANUARY 1, 1981.

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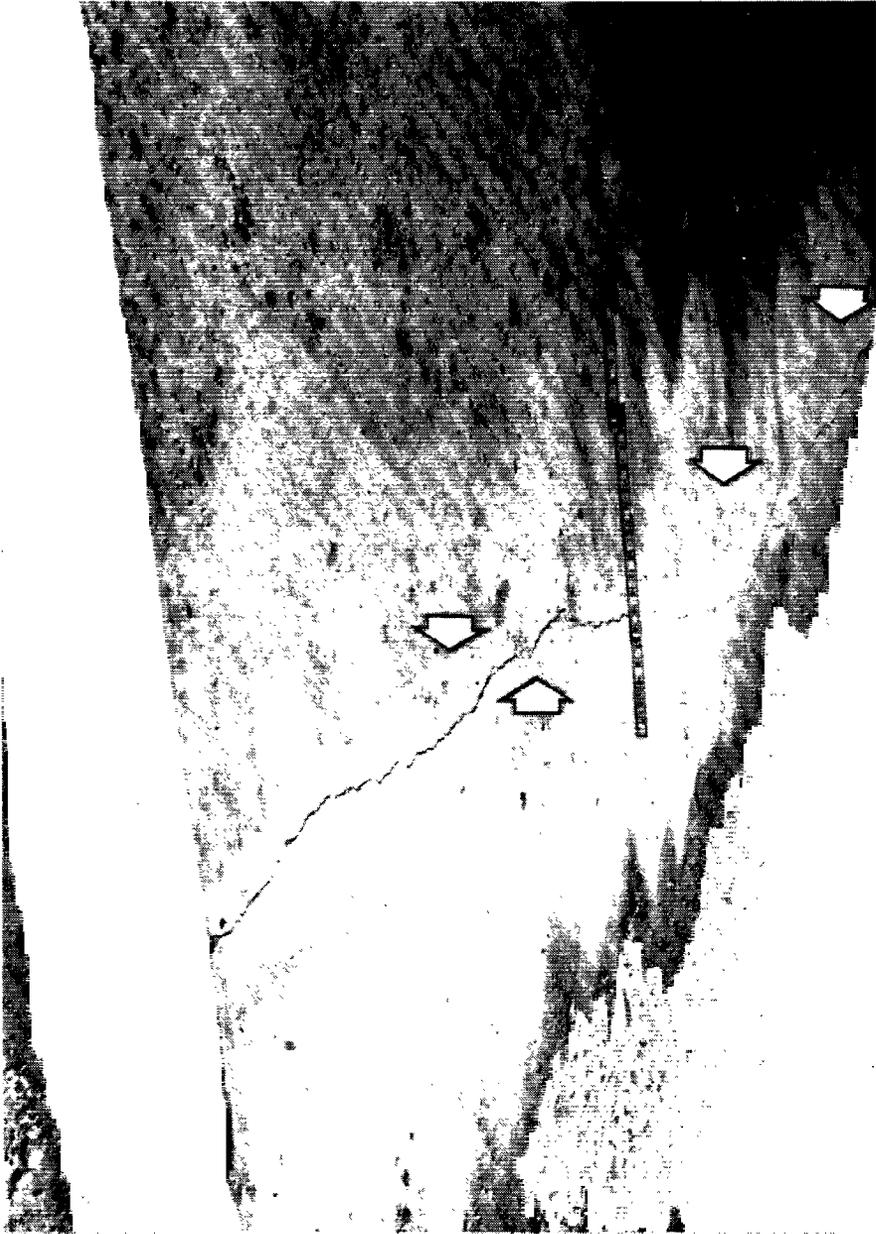
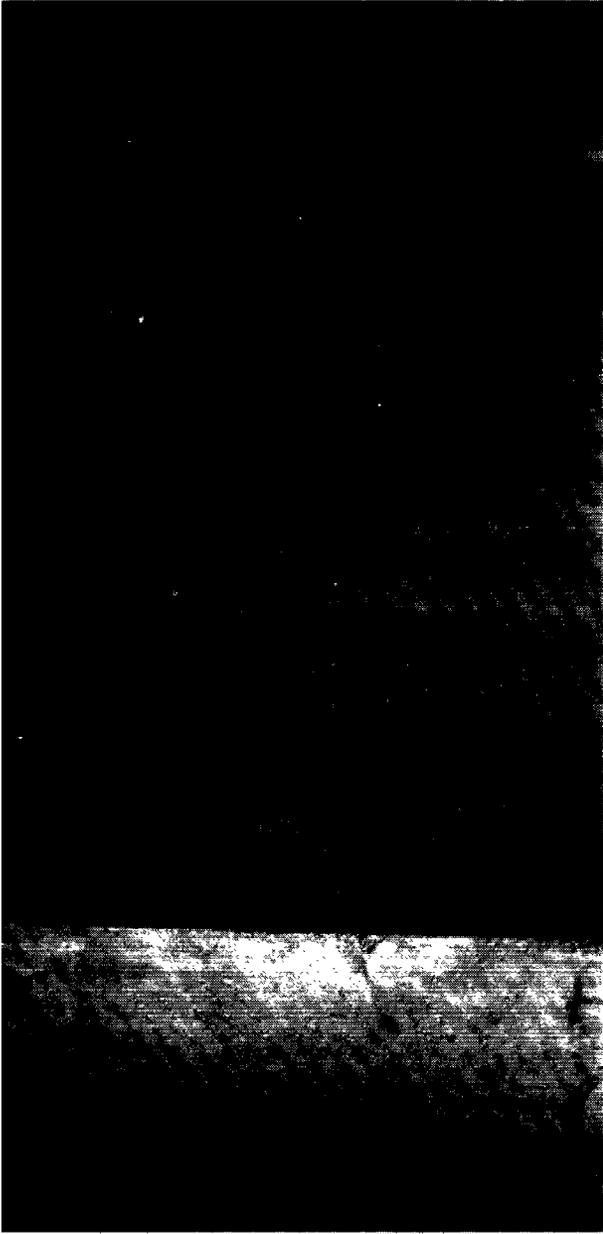
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FEDERAL OFFICE BUILDING AND COURTHOUSE, SPRINGFIELD, MASS.
PHASE I NEAR COMPLETION. VIBRATORY HAMMER REMOVING SHEETING FROM BRIDGE STREET AS OF JUNE 2, 1981

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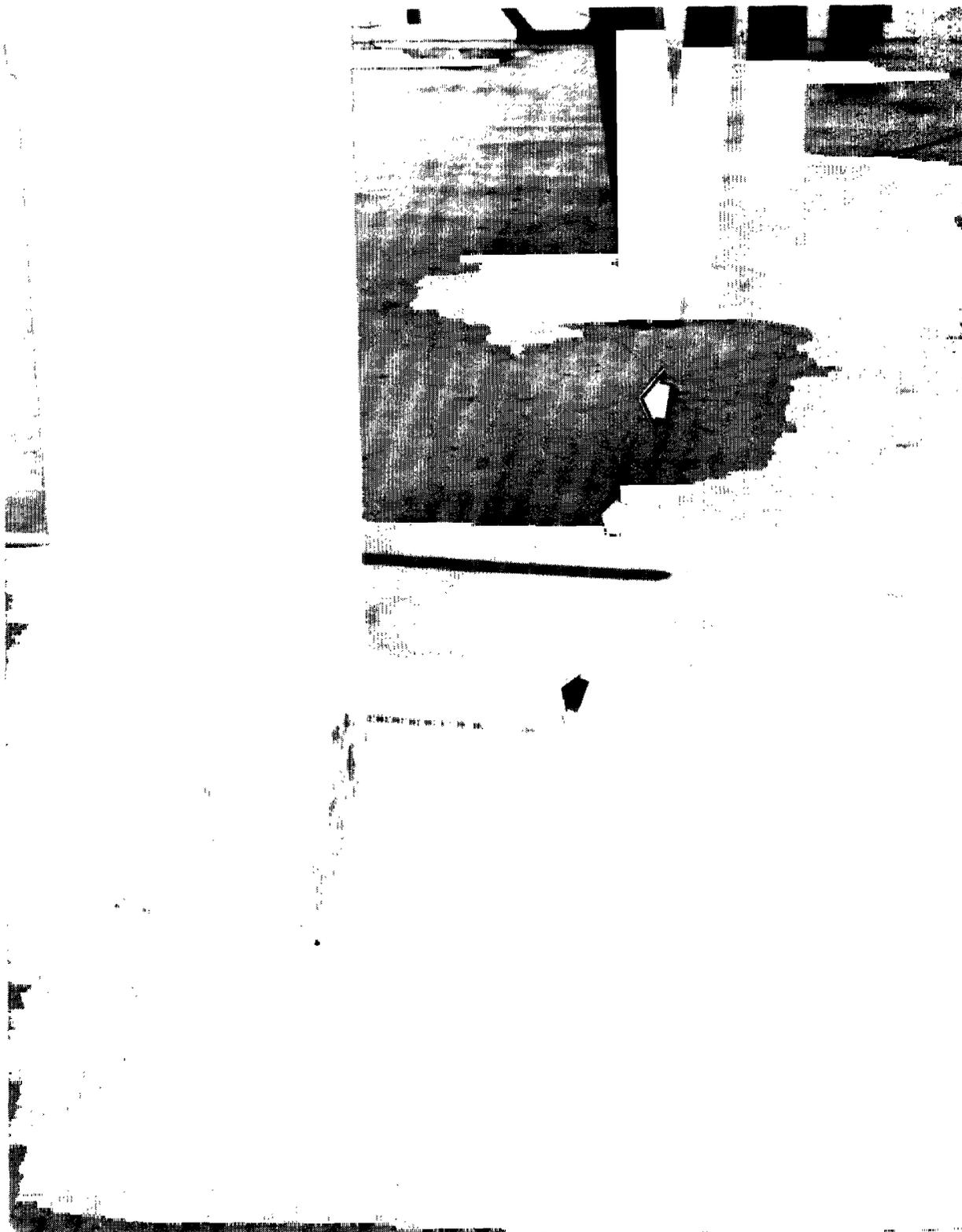
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FEDERAL OFFICE BUILDING AND COURTHOUSE, SPRINGFIELD, MASS.
CRACK IN BASEMENT SLAB NEAR COLUMN 13.

ENCLOSURE

ENCLOSURE



FEDERAL OFFICE BUILDING AND COURTHOUSE, SPRINGFIELD, MASS.
CRACK ON 5TH FLOOR NEAR COLUMN H5.

The phase I contractor stated that throughout the construction, it worked closely with the design contractor resident and the GSA resident engineer and operated in accordance with the specifications and drawings. The contractor also stated that it did not question the design of the structure, particularly the foundation.

The design contractor's geotechnical engineer, GZA, was requested to make a systematic evaluation of the foundation settlement problem. The evaluation, dated July 23, 1981, concluded that:

- Excessive settlements of the ground beneath some footings near Worthington, Main, and Bridge Streets were the result of extraction of nearby sheet piling by the vibratory hammer.
- Excessive settlements which occurred below some portion of the basement floor slab near Worthington and Bridge Streets were also the result of extraction of nearby sheet piling by the vibratory hammer.

The evaluation recommended that a prudent, interim action would be to fill the voids to stabilize the foundation problems until final remedial actions can be planned and coordinated. The phase I contractor immediately filled the voids. The design contractor transmitted GZA's evaluation to GSA and stated that the building structure and foundation posed no threat to public safety and were generally sound for present loads. The design contractor recommended that the remaining sheeting be left in place as part of any remedial action.

The design contractor, the phase I contractor, and GSA accepted the findings of GZA's evaluation that the foundation settlement problem was caused by the vibratory hammer during the extraction of the sheet piling. GSA notified the phase I contractor of its responsibility for any corrective action that was necessary. The contractor accepted the conclusions of the GZA evaluation, but believes that the natural condition of the soil contributed to the foundation settlement problem. The contractor said it would correct the problem, but would do so under protest.

At our request, geotechnical engineering branch officials of the Corps of Engineers' New England Division reviewed the two GZA geotechnical studies. Corps officials told us that there was nothing unusual about using a vibratory hammer to extract the sheet piling, but that the foundation settlement problem resulted from the use of the vibratory hammer. Corps officials and a Carter representative told us that it is normal construction practice to remove sheeting when construction is completed.

During our site visits, we noted that the foundation settlement problems and cracks occurred along Worthington and Main Streets where Carter used the Foster 40E electric vibratory hammer to drive the sheeting the first 15 feet into the ground. We also noted that where the more powerful MKT V-16 vibratory hammer was used to drive the sheeting the first 25 feet into the ground along Main and Bridge Streets, no foundation cracks occurred and the settlement near Bridge Street was minor by comparison.

EFFECT ON CONSTRUCTION SCHEDULE

The phase I contractor was scheduled to complete work by June 21, 1981. When the problem was discovered on June 10, 1981, the contractor had substantially completed all work except for the pouring of concrete on the penthouse and roof, the removal of sheeting, and some street work. We believe the contractor would probably have met the June 21, 1981, completion date.

The phase I contractor retained a firm to pump compaction grouting under the foundation to correct the settlement problem. Two interior columns were raised to acceptable levels, but the foundation wall along Worthington Street was not elevated to the desired level. No further attempt will be made to correct the problem by the compaction grouting method. Subsequently, the contractor decided to bring the floors to the desired level by pouring 2-1/2-inch concrete fill on the five floors. The contractor was preparing to do this at the time we completed our review.

A Public Buildings Service Region I official gave the following reasons GSA authorized the phase II contractor to begin construction, rather than to delay until the problem was corrected:

- GSA issued on April 28, 1981, a notice to proceed to the phase II contractor, and according to the contract, GSA had up to 60 days, or June 27, 1981, to issue the site notice to proceed. After the discovery of the settlement problem on June 10, 1981, GSA delayed issuance of the site notice until June 26, 1981. However, GSA believed that if it did not issue the notice, the contractor could submit a claim for the costs incurred resulting from the issuance of the notice to proceed.
- GSA believed that the phase I contractor would be able to correct the foundation problem quickly and that the corrective action would not interfere with the phase II construction work.

During our visit to the site on November 10, 1981, the GSA resident engineer said that the phase II contractor had been able to work around the problem, that the precast concrete panels would be installed without any schedule delay, and that the phase I contractor was preparing to pour the concrete fill on the five floors.

COST IMPLICATIONS

GSA has not been able to assess the total cost implications for correcting the settlement problem, but has collected the following information:

- Cost for the compaction grouting remedy is estimated between \$50,000 and \$80,000 to correct the Worthington Street side.
- The phase I contractor will incur costs for the concrete fill on the five floors.
- The phase I contractor has incurred costs to dig test pits, examine under the footings, and place grouting under all footings where voids were discovered.
- Future costs may be incurred to repair city streets and damages to existing utility property.
- The cost of sheeting left in the ground is estimated at \$52,000, with an additional \$5,000 to cut off the tops of the sheeting.
- The design contractor will submit a claim for all costs incurred beyond the scope of the original contract.

A Public Buildings Service Region I official told us that the prospective tenants of the building are currently housed in two Government-owned buildings and three leased buildings. One lease, with an annual rent of \$14,756, will expire November 30, 1982. If the new building is not ready for occupancy by then, arrangements will have to be made to house the agencies in this leased building. If GSA remains at the same leased location or moves to alternative leased space, additional costs will be incurred. The other two leases will expire in 1982, but can be renewed for an additional 2 years. The annual rent for the two leases is \$34,914 and \$163,171. If the occupancy date for the new building is delayed, it will be necessary to renew the two leases. If renewed, GSA will incur additional costs.