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MONITORING A CRIBLOCK RETAINING WALL

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16. Abstract

Two criblock retaining walls were constructed on both ends of a bridge on Project BRO 0057(2) on County Road 17 in Pitkin County in western Colorado.

This study was initiated to evaluate the post-construction performance of this proprietary retaining wall system. The walls were completed during March 1989, and their movements were monitored through July 1990.

The results of the monitoring program indicated that the wall movements were limited to less than 3/4 of an inch during the 17 months monitoring period, and the walls appear to be in satisfactory working condition. The appearance of the criblock retaining walls as well as their durability can make this retaining wall system competitive with the other retaining wall systems when applicable.

Implementation

This report will be distributed internally to allow the staff bridge design group, as well as other branches in the Highway Department, to make their own determinations based on the observations of this study.

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I. INTRODUCTION

The Project BRO 0057(2) consisted of a bridge replacement and two retaining walls constructed on a county road in Pitkin County, Colorado. This project was designed by a consultant, Integrated Engineering Consultants, for Pitkin County. The consultant proposed and designed the two concrete cribwalls utilizing a criblock system at each end of the bridge. This type of retaining wall was requested by Pitkin County for this project due to the fact that the criblock design would be more compatible with the aesthetics of the project site.

Due to the proprietary nature of the concrete criblock retaining wall system, and the requirements of the FHWA concerning proprietary retaining walls, it was proposed to consider the criblock walls as experimental features during this project. Therefore, this research study was initiated to monitor the installation and the long-term performanmce of the criblock retaining walls for future references.

II. BACKGROUND

A. Mechanics of a Concrete Criblock Retaining Wall

A criblock retaining wall is basically a gravity-type retaining structure with a face consisting of a grid of precast reinforced concrete members, as shown in Figure 1. The face is generally inclined at a slope of four vertical to one horizontal (unless otherwise specified). Horizontal members of such a grid are termed "front strechers". Where non-standard

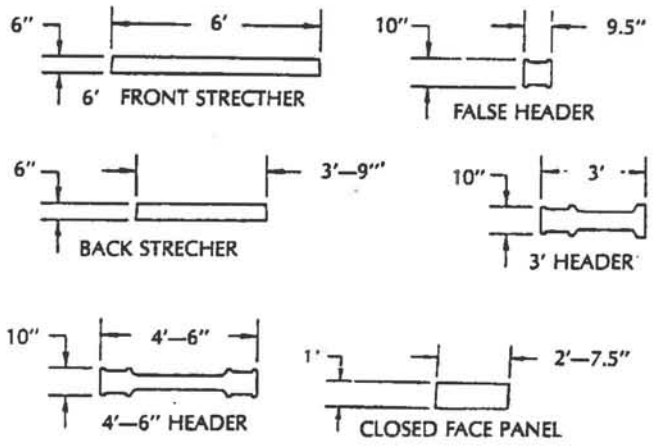


Figure 1.a Components of a criblock retaining wall

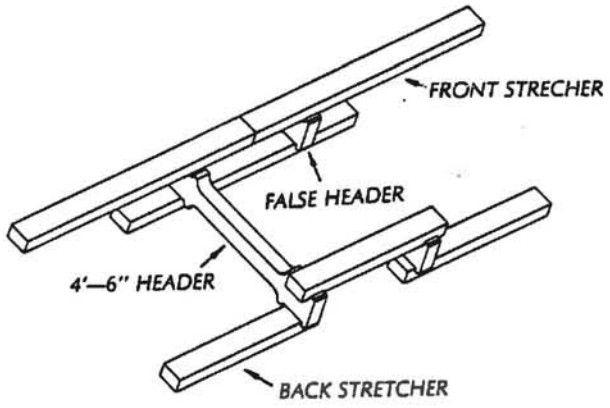


Figure 1.b Partial structure of a cribwall

Figure 1. Illustration of components and formation of a cribwall

stretcher lengths are required to complete the end of a wall, they are termed "closers". The face members are connected by transverse members termed "headers" to a similar grid of "back stretchers" parallel to the face and located so that the overall thickness of the wall is not less than three feet. To complete the wall, some additional spacers, termed false headers, may also be used if the system requires it. Headers are to be perpendicular to the face of the wall.

B. History of Criblock Retaining Walls

The criblock retaining structures were introduced to the United States over a decade ago. Europe has played a bigger role in developing this technology, but the first documented case history goes back to 1966[1] in Australia. The literature obtained on this case history indicated that the first wall was built in Australia and it consisted of concrete panels to complete the wall.

During the past two decades, the criblock idea has been used to build various retaining structures utilizing various elements such as concrete panels, treated wood members, or used tires. The American Wood Preservers Institute reports of another project[2] which consisted of building a 22 foot high retaining structure with treated wood members bolted together and filled with rock or other suitable material. The Institute of Civil Engineers also reports of a case history[3] where used tires were used to build a crib wall 40 M long and 3.7 M high to form a flat parking area. The unusual construction detail of the wall concerns the use of some 4,000 used tires, which were laid by five men and two mechanics at a rate of up to

360 tires per 8 hour day. First, a layer of tires was placed to give maximum interlock with the previous layer, using link bars where necessary. Then, a crawler loader placed shale and siltstone fill over the tires, and workers shovelled the fill into the tires. Finally, a Bomag vibrating roller compacted and leveled the fill. The sequence was then repeated for each layer of tires.

The use of criblock retaining walls using concrete panels has become more popular, and it has found many commercial applications. Some of these commercial applications include:

a. Highway Applications
b. Slot-cut Walls
c. Sound Barrier
d. Multiple Depth Construction/and
e. Landscaping.

III. PROJECT LOCATION AND GEOLOGY

The Project BRO 0057(2) was located on County Road 17, in Pitkin County, as shown in Figure 2. Construction during this project consisted of replacing the Gerbiz bridge across the Roaring Fork River, northwest of Woody Creek. The new bridge replaced the old bridge about 20 feet upstream, as shown in Figure 3.

Chen and Associates was selected to perform the geological study of the site and make recommendations on the types of foundations appropriate

STATE DEPARTMENT OF HIGHWAYS
DIVISION OF HIGHWAYS—STATE OF COLORADO

PLAN AND PROFILE OF PROPOSED

FEDERAL AID PROJECT NO. BRO-0057(2)

COUNTY ROAD NO.17

PITKIN COUNTY

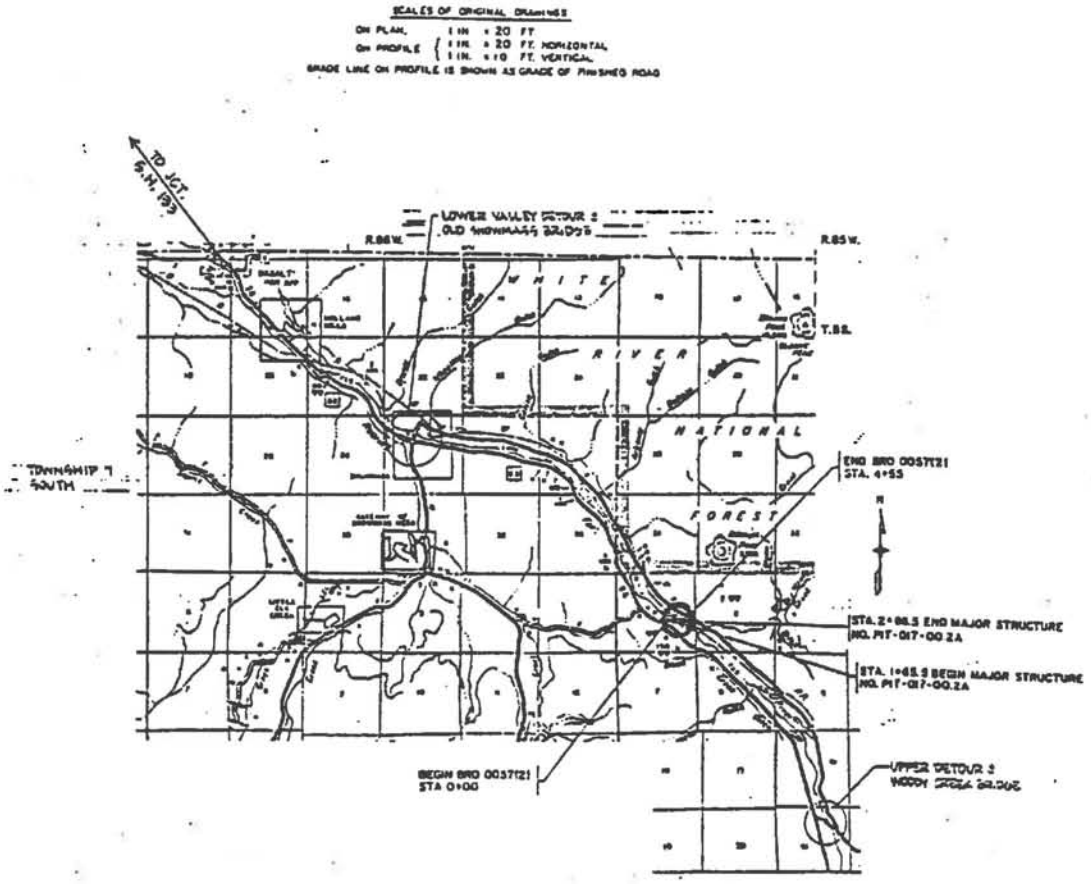


Figure 2. geological location of project BRO 0057(2)

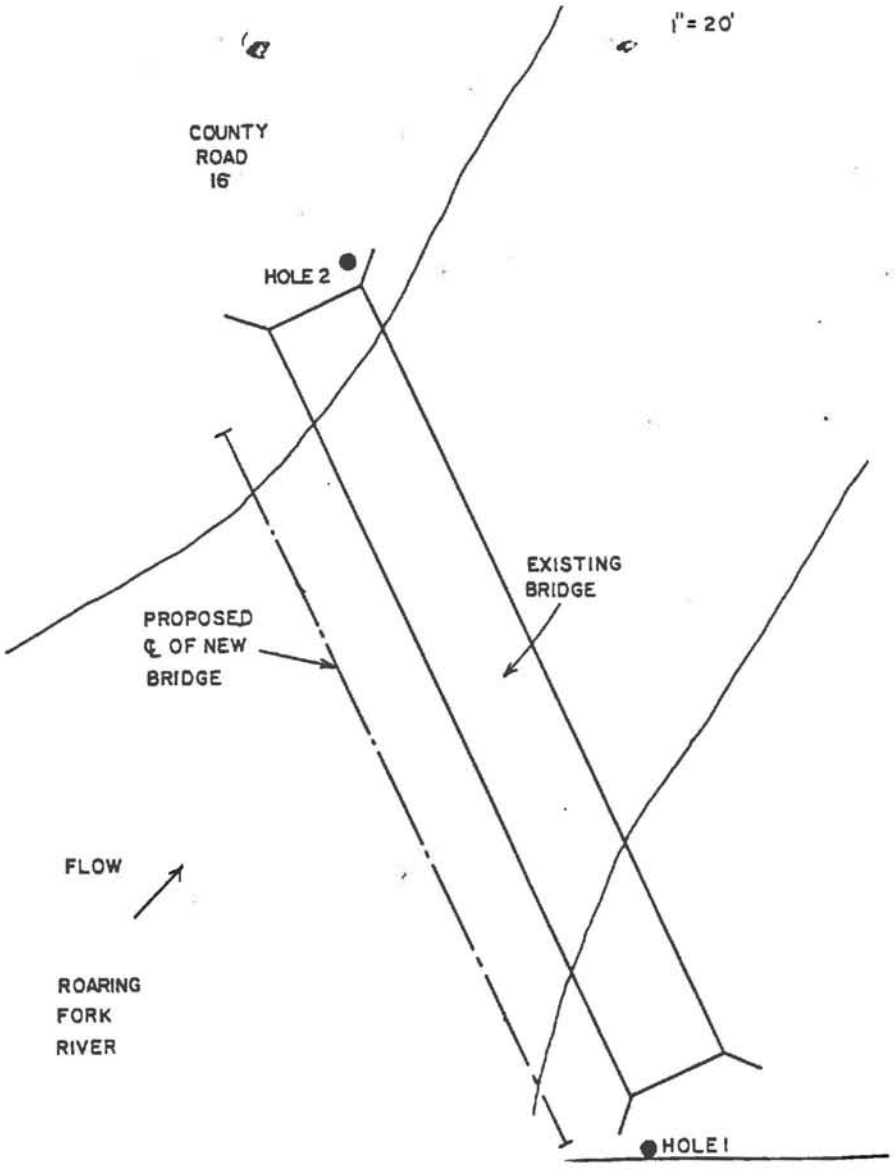


Figure 3. Skematic of the location of the new bridge relative to the old one

for this project.

The results of the geological study indicated that the subsurface conditions encountered at the site consisted of a variable depth of man-placed fill overlying natural gravels and cobbles at the east abutment boring and sandstone bedrock at the west abutment boring. Ground water was encountered at the river elevation in the boring near the east abutment.

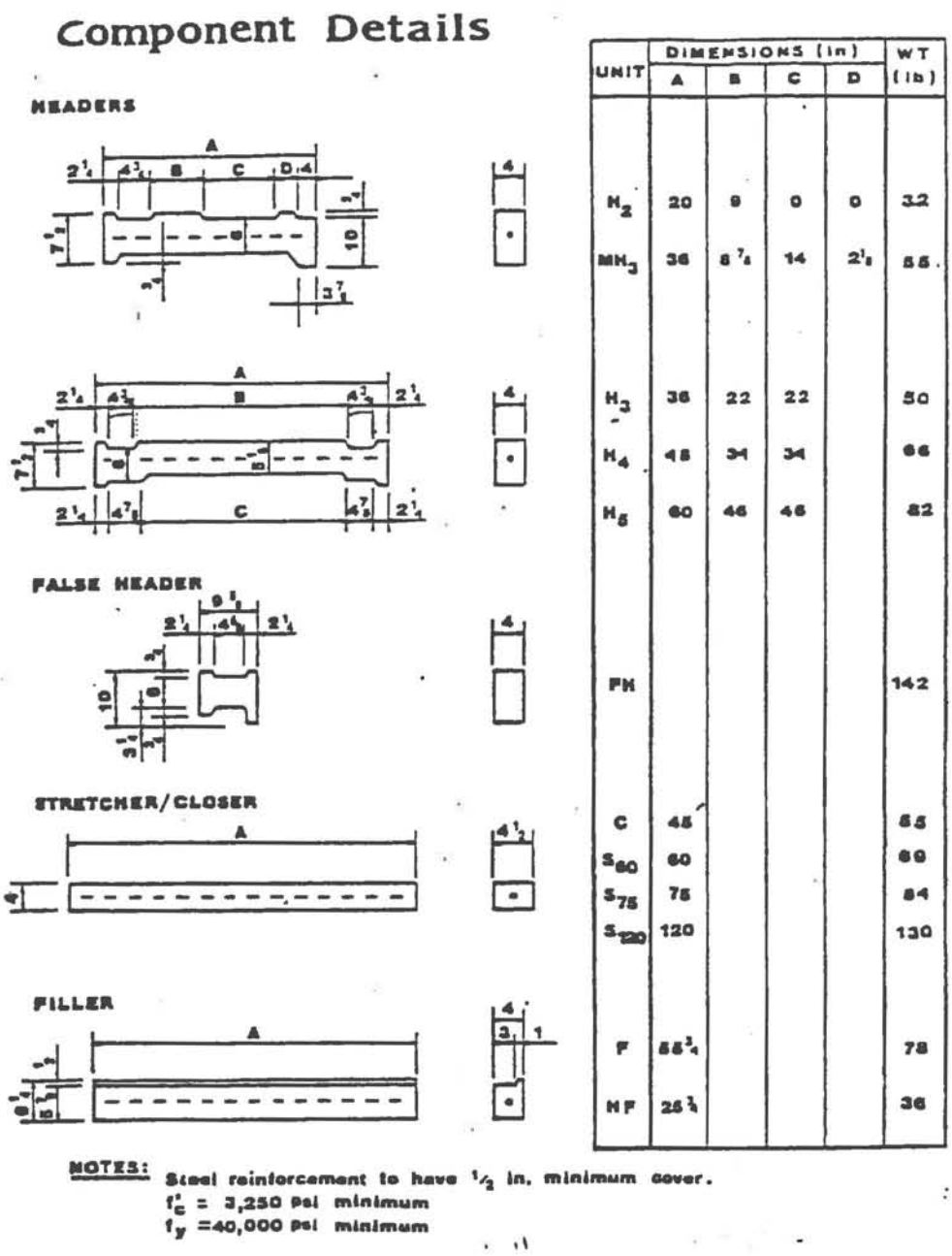
Based on the laboratory testings and the field observations, it was recommended to use spread footing foundations for both abutments to support the bridge structure. It was also calculated that the spread footings may undergo a total settlement of one inch or less which was categorized as being acceptable.

Based on the above field investigation and the request of the county, it was decided to build two criblock retaining walls to retain the soil on both ends of the bridge and provide an aesthetically desirable look for the environment.

IV. CONSTRUCTION

For this project, the two criblock retaining walls were designed by "retention engineering" and they were constructed using the pre-cast reinforced concrete crib members as shown in Figure 4.

The wall on the east end of the river was designed to be 95 feet long and 10 feet high. The segment on the west end of the river was much smaller



UNIT	DIMENSIONS (in) A	B	C	D	WT (lb)
H_2	20	9	0	0	32
MH_3	36	8 7/8	14	2 1/8	55
H_3	36	22	22		50
H_4	48	34	34		66
H_5	60	46	46		82
FH					142
C	48				55
S_{60}	60				69
S_{75}	75				84
S_{120}	120				130
F	55 3/4				78
HF	25 3/4				36

Figure 4. details of the pre-cast reinforced concrete crib members

in length, but was designed to be a few feet higher compared to the one on the opposite side. Figure 5 shows the details of the cribwalls for this project.

The construction of a cribwall is basically an easy process. The originators of cribwalls would like to think of this process as a "one man, one block" operation. The most important criteria to consider is the preparation of the cribwall base. No special concrete slabs are required, but the base needs to be cleaned and perfectly leveled to the required grade so that the first cribwall components are placed on the top of a uniform and firm base providing an adequate foundation for the rest of the wall.

To begin the wall construction, an appropriate amount of excavation was performed on both ends of the bridge for placement of the criblock components. Excavation on the west end of the river was carried out with an extreme amount of difficulty due to the presence of sandstone near this end of the bridge.

The base of the walls was cleaned and compacted using vibratory hand compactors as shown in Figure 6. Additional soil, gravel, or a mixture was placed and compacted to create the four vertical to one horizontal slope at the wall base. During this project, four to five inches of sandy gravel was used as base material at the bottom of the walls due to the high ground water elevation encountered at the river level. Figure 7 shows the sandy gravel blanket prior to construction of the walls.

Once the base preparation was completed, the rest of the wall was

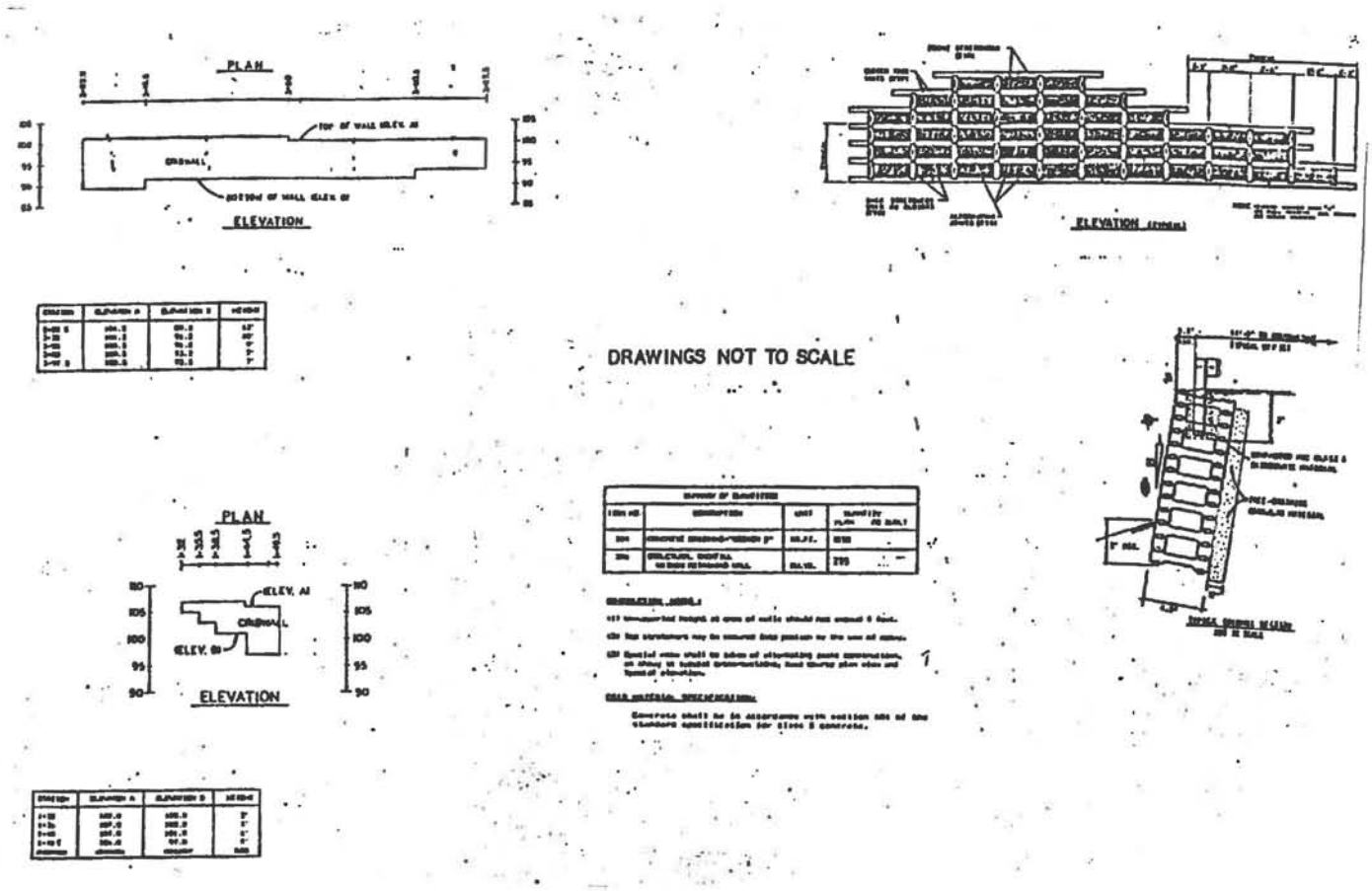


Figure 5. Details of the cribwalls in project BRO 0057(2)

Figure 6. Foundation preparation for the east wall

Figure 7. Placement of granular soil at the base of the wall

erected without much difficulty. The cribwall members were handled by the laborers present at the site by simply stacking them on top of one another and making sure the alignment and the required grade were preserved.

The first course of cribwall units was the front and back stretchers (or closers). This step was carefully done to ensure firm bedding against the base soils. Figure 8 shows the placement of front and back stretchers at the east end of the large cribwall.

The cribwall cells were placed in horizontal lifts and they were backfilled after placement of maximum three lifts. The backfill soils consisted of granular soils with a large percentage of gravel and free from organic material. The backfilling was accomplished by a front loader slowly pouring the backfill soil into the completed cribwall cells.

The next step was to compact the backfill soil contained in the cells. This was done by using a special hand-held vibrator small enough to be placed inside the cells and provide 85 percent or higher of AASHTO T-99 compaction at optimum moisture content. The compaction effort was performed for each foot of backfill soil which was poured into the cribwall cells. Figures 9 to 16 show the progress of the cribwall construction on the east end of the river.

The construction of the cribwalls followed a simple procedure and required no heavy equipment for completion of the walls. The crib members consisted of precast, reinforced concrete elements light enough to be handled by one man. The base of the walls required no special treatment

Figure 8. Placement of the front and back strechers for the east wall

Figure 9. Close-up view of the concrete cribwall components

Figure 10 construction of the east wall in progress

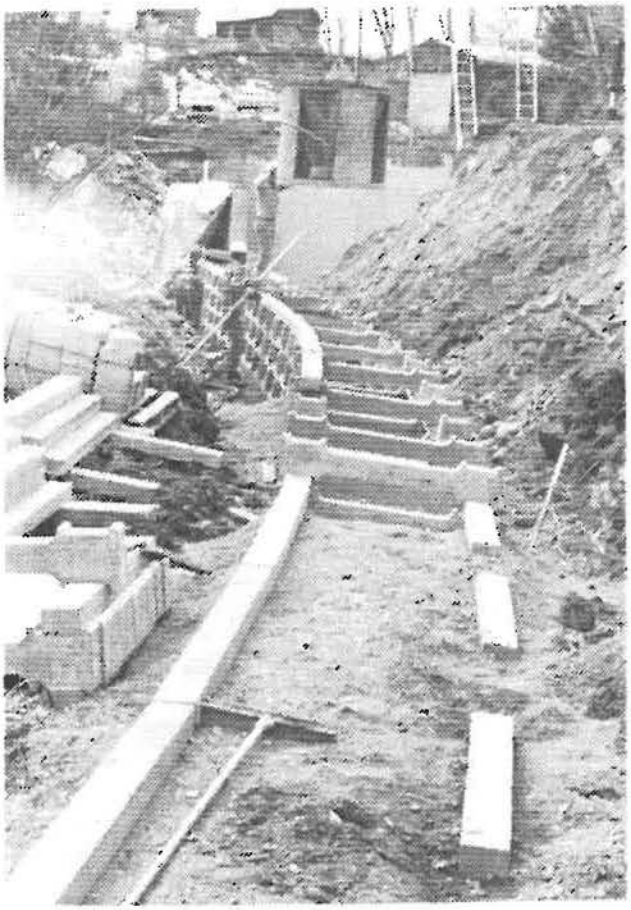


Figure 11 contrast in elevation at different lacations of the east wall

Figure 12 pregress of the east cribwall

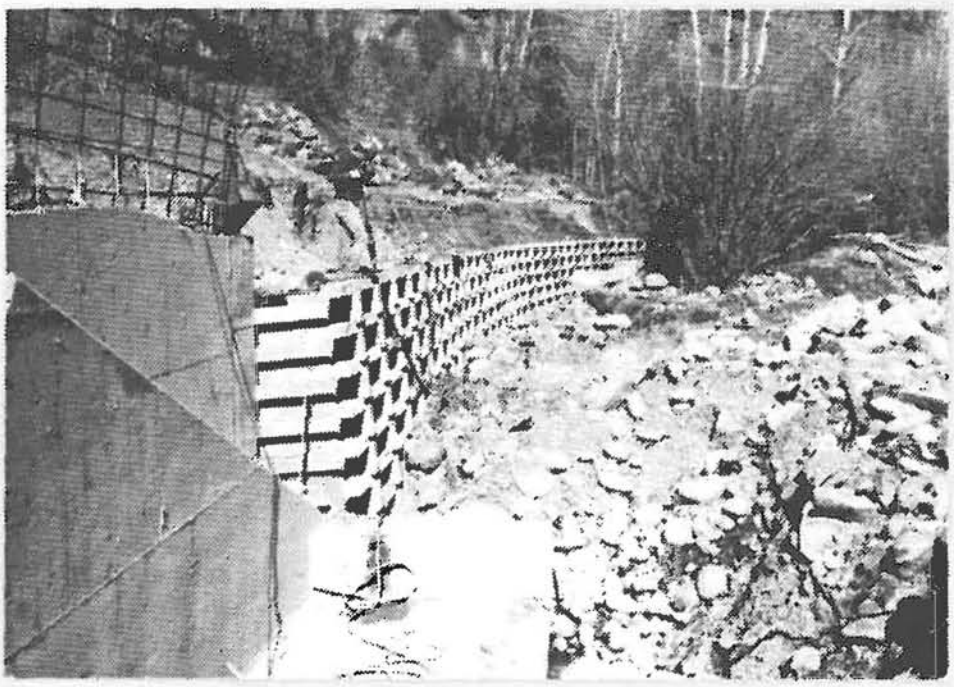


Figure 13 compaction of the soil inside the concrete blocks

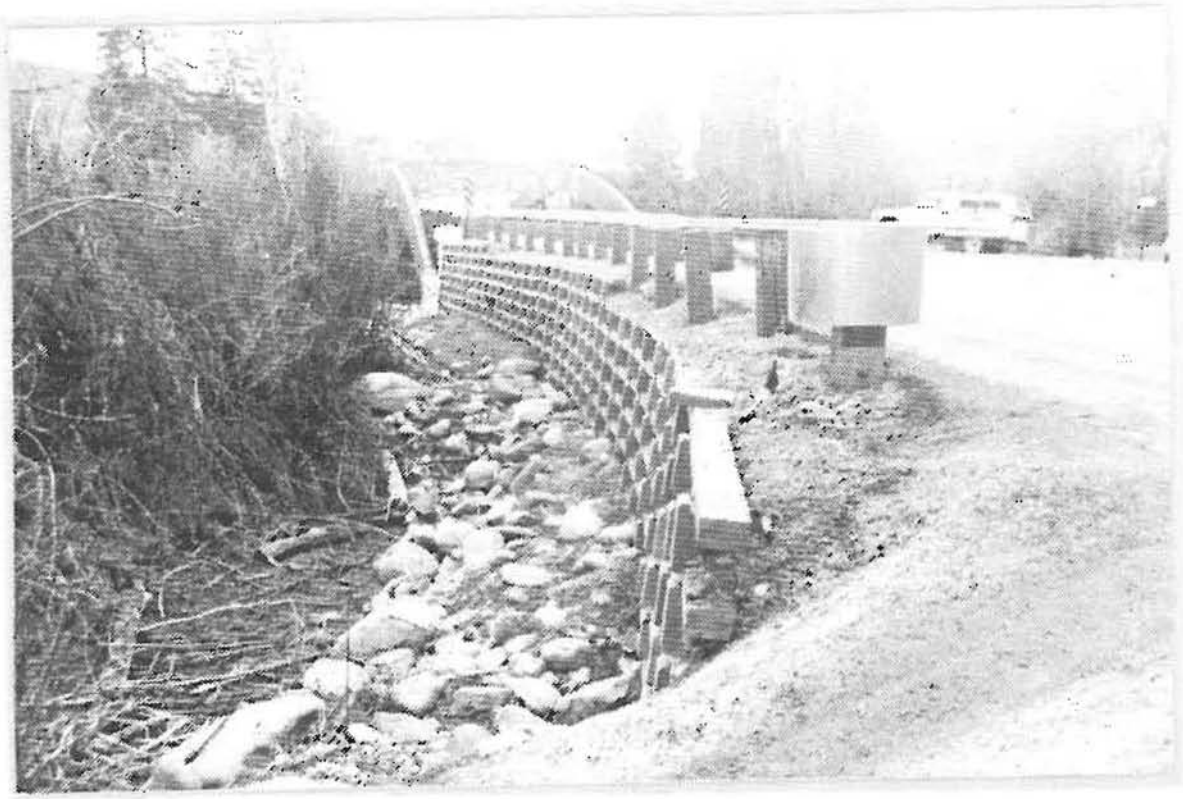


Figure 14. completed east cribwall

Figure 15. completed west cribwall

Figure 16 view of the completed structures on project BRO 0057(2)

except leveling and placing some granular soils to act as a drainage blanket during the high ground water table.

The crib members were handled by the laborers present on the job site. Each laborer could carry one element to its designated location where qualified personnel were building the crib cells by stacking them on top of each other in an orderly manner. The rest was to level, maintain the grade, backfill, and compact the soils according to the provided specifications.

No major difficulties were encountered during the construction, and the walls were completed in less than 10 working days.

The walls were estimated to cost $15 per square foot of wall face, but they were bid at $17 per square foot. Based on our experience, this cost seemed to be competitive with the costs of other retaining wall systems. Therefore, the construction of the concrete criblock retaining walls was approved on an experimental basis, and both walls were monitored to determine their long-term performances.

V. MONITORING AND DATA ANALYSES

After completion of the walls, one station on the west wall and three stations on the east wall were selected for monitoring of the future wall settlements. At each station, three points on the top, middle, and lower part of the wall were selected for monitoring as shown in Figure 17.

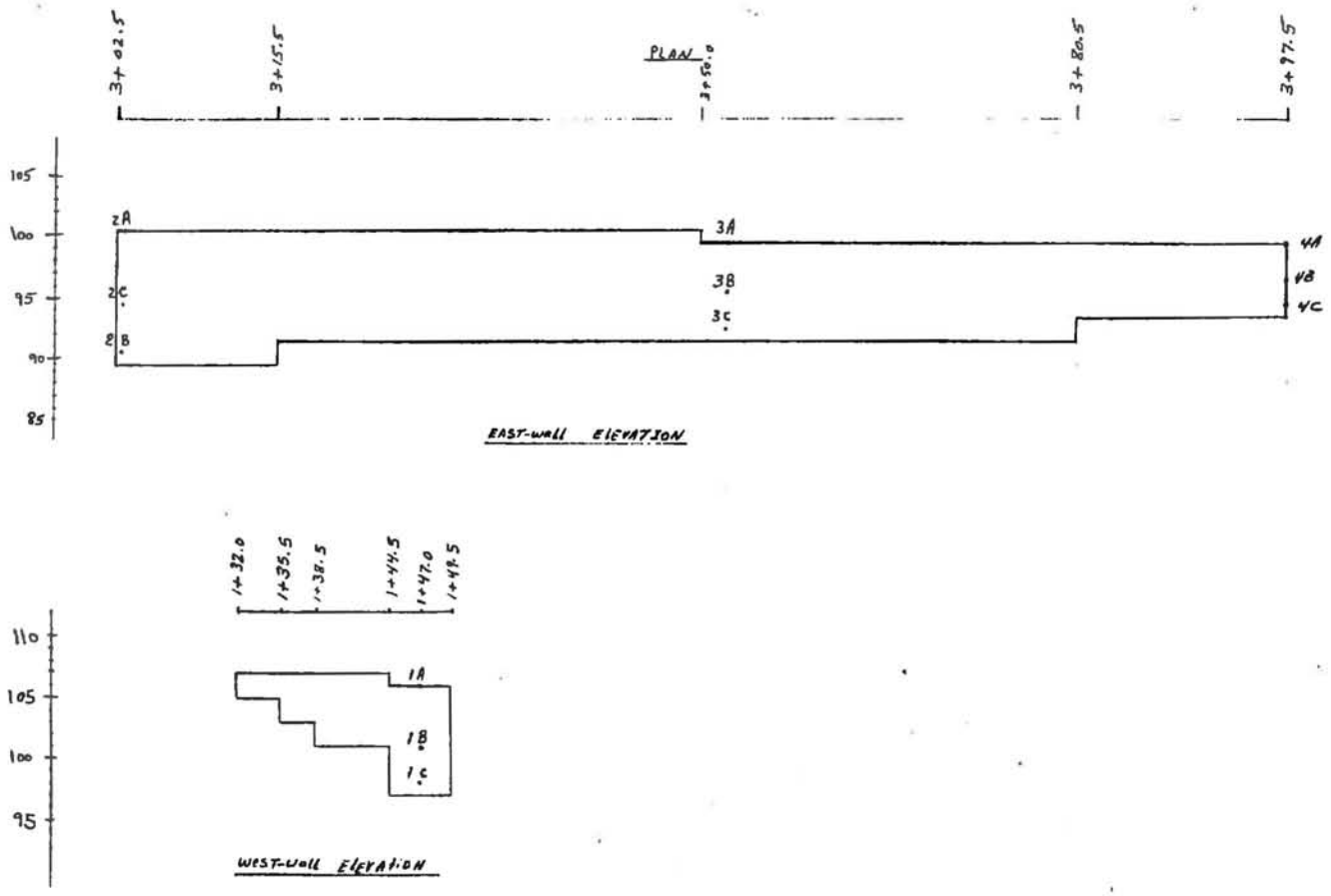


Figure 17. elevation points on the east and west walls

All points were monitored for vertical settlement using the standard survey techniques and the results are presented in Table 1.

The survey results indicated that during the 14 months following the construction of the walls, a maximum of 0.05 and 0.06 feet of settlements had occurred on the east and west walls, respectively. These settlements were considered to be negligible and tolerable by the walls.

The crib members at the face of the walls (front stretchers) appeared to be in good shape except for two locations where they had lost some alignment due to local settlement and adjustment of the backfill soils behind the walls. This can be seen in Figure 18. These local realignments occurred immediately after the walls were completed, and they did not improve during the 14 months monitoring period.

VI. CONCLUSIONS

a. The criblock retaining walls are easy to build, and they require no special heavy equipment for completion of walls.

b. The cost of a criblock retaining wall is competitive with the other retaining walls built by the CDOH.

c. Criblock retaining walls can be aesthetically pleasing. If the backfill soil is appropriate, some local plants and vegetation can be planted onto the cells at the front face to further improve the image of the concrete blocks.

CRIBWALL SETTLEMENT DATA PROJECT BRO 0057(2)

DATE	STATION 1+47			STATION 3+03			STATION 3+52			STATION 3+98		
	1A	1B	1C	2A	2B	2C	3A	3B	3C	4A	4B	4C
05/02/89	106.81	102.77	98.73	101.18	96.17	92.14	100.23	96.21	93.22	99.20	96.19	93.18
05/18/89	106.80	102.76	98.72	101.16	96.16	92.13	100.23	96.17	93.20	99.20	96.17	93.15
05/31/89	106.81	102.77	98.73	101.20	96.16	92.12	100.23	96.20	93.20	99.19	96.18	93.16
07/25/90	106.75	102.72	98.67	101.18	96.14	92.12	100.22	96.19	93.19	99.16	96.14	93.13
SETTLEMEN	0.06	0.05	0.06	0	0.03	0.02	0.01	0.02	0.03	0.04	0.05	0.05

TABLE 1. THE RESULTS OF THE SURVEY DATA

Figure 18 separation of the concrete blocks due to settelment of the foundation soils

VII. IMPLEMENTATION

Based on the experienced gained during this study, the cribwall system is suitable where the subsoils beneath the wall are stable and will not experience significant settlement due to the weight of the wall. Therefore, this retaining wall system should be included as an alternative design in the CDOH Retaining Wall selection process.

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