LEGACY REPORT

ER-5087

Reissued March 1, 2006

ICC Evaluation Service, Inc.
www.icc-es.org

Business/Regional Office ■ 5360 Workman Mill Road, Whittier, California 90601 ■ (562) 699-0543
Regional Office ■ 900 Montclair Road, Suite A, Birmingham, Alabama 35213 ■ (205) 599-9800
Regional Office ■ 4051 West Flossmoor Road, Country Club Hills, Illinois 60478 ■ (708) 799-2305

Legacy report on the 1997 *Uniform Building Code™*

DIVISION: 02—SITE CONSTRUCTION
Section: 02830—Retaining Walls

ALLAN BLOCK RETAINING WALL SYSTEM

ALLAN BLOCK CORPORATION
5300 INDUSTRIAL BOULEVARD, SUITE 100
EDINA, MINNESOTA 55439

AIR VOL BLOCK
1 SUBURBAN ROAD
SAN LUIS OBISPO, CALIFORNIA 93401

CALSTONE COMPANY
1155 ASTER AVENUE
SUNNYVALE, CALIFORNIA 94086

ORCO BLOCK COMPANY, INC.
4510 RUTILE STREET
RIVERSIDE, CALIFORNIA 92509

1.0 SUBJECT

Allan Block Retaining Wall System.

2.0 DESCRIPTION

2.1 General:

The Allan Block Retaining Wall System encompasses materials and methods for constructing gravity retaining walls, reinforced masonry retaining walls and geogrid-reinforced retaining walls. See Figure 1 for a typical section of an Allan Block Retaining Wall System. Four Allan Block types are recognized in this report, and are identified as the AB Stones, AB Classic, AB Three, and AB Rocks. Figure 2 provides block dimensions and weights. All units comply as Grade N, Type I in accordance with UBC Standard 21-4, with a minimum 28-day compressive strength of 3,000 psi (1.2 MPa) on the net area and a maximum water absorption of 6 percent. Block tolerances comply with Section 21.406 of UBC Standard 21-4.

2.2 Design:

The system is designed as a reinforced, soil retaining wall system that depends upon the weight and geometry of the reinforced soil mass to resist lateral earth pressures and other lateral forces. Lateral earth pressures are determined using either the Coulomb theory or the Rankine theory. The design must include evaluation of both external and internal stability and must also include consideration of external loads such as surcharges and seismic activity. External stability analyses are similar to those required for conventional gravity retaining walls. Minimum safety factors are 1.5 for sliding, 2.0 for overturning and 2.0 for bearing capacity. Internal stability analyses must consider allowable reinforcement tension, pullout resistance of the reinforcement behind the active failure zone and the strength of reinforcement connections at the facing.

A foundation investigation in accordance with Section 1804 of the code is required for each site. The foundation investigation determines the soil properties and the values for design. The design method is based primarily on accepted geotechnical engineering principles. Details are in the Federal Highway Administration report "Design and Construction Guidelines for Reinforced Soil Structures, Volume I," dated November, 1989, FHWA Report No. FHWA-RD-89-043 (FHWA Design Manual); the National Concrete Masonry Association report "Design Manual for Segmental Retaining Walls" dated 1997, NCMA Report No. TR 127A/ISBN 1-881384-07-1; and the Allan Block engineering manual for "Allan Block Retaining Wall Systems," dated 1999.

2.2.1 Gravity Retaining Walls: The gravity wall system depends on its weight and geometry to counteract the lateral earth pressure and other lateral forces. Gravity wall design shall be based on standard engineering principles. Maximum wall heights are shown in Table 1.

2.2.2 Reinforced Masonry Retaining Walls: The design of reinforced masonry retaining wall systems must comply with Chapters 16 and 21 of the UBC. The system is designed as a steel-reinforced wall that depends on traditional reinforced masonry to resist lateral earth pressures and other lateral forces.

2.2.3 Geogrid-reinforced Retaining Walls: This system is designed as a reinforced soil-retaining wall system that depends on the weight and geometry of the reinforced soil mass to resist lateral earth pressures and other lateral forces. The design must include evaluation of both external and internal stability. External stability analyses are similar to those required for conventional gravity retaining walls. Internal stability analysis must consider allowable geogrid reinforcement tension, pullout resistance of the geogrid reinforcement behind the active failure zone and the strength of the geogrid reinforcement connections at the block facing.

2.3 Assembly:

The angle of wall inclination is approximately 3 to 12 degrees from vertical toward the backfill as determined by the setback per course provided by the block lip. The block foundation is either leveled subgrade material consisting of at least 6

inches (152 mm) of granular fill compacted to at least 95 percent of the maximum dry density determined by ASTM D 698; unreinforced concrete complying with Sections 1915.11, 1922.7 and 1922.8 of the UBC; or reinforced concrete complying with Section 1915 of the UBC. Specific foundation requirements for each site must be determined by the soils engineer. See Figure 3 for typical details.

Details in this report are limited to areas beyond groundwater. Footings in groundwater are contingent on appropriate soil and engineering analysis reports being submitted to the building official for approval.

Backfill used in the reinforced fill mass must consist of cohesionless granular material placed in compacted lifts. The backfill soil properties, lift thickness, degree of compaction and width behind the block are determined by the soils engineer. If the retained soil or backfill has poor drainage qualities, granular drainage layers and/or perforated drains must be installed to prevent buildup of hydrostatic pressures behind the wall. Provisions for drainage must be determined by the soils engineer.

Blocks are stacked and aligned using the vertical lip at the lower front edge. The top units are set back approximately $^3/_8$ to $1^1/_2$ inches (9 to 38 mm) from the lower units and are guided by the lip. A minimum offset of 3 inches (76 mm), horizontally, is maintained between the head joints of adjacent courses of block. The completed wall is built with alignment tolerances of $^3/_4$ inch in 10 feet (19 mm in 3048 mm) in both the horizontal and vertical directions.

Blocks may be assembled with an inside or outside curved layout. Minimum inside curve radius is 4 feet (1219 mm), and minimum outside curve radius is 4 feet (1219 mm).

When used, geogrid reinforcement is placed at the elevations specified in the design. The backfill surface must be placed and compacted to a level approximately 1 inch (25 mm) below the top block elevation where geogrid placement is required. The geogrid is embedded a minimum of 8 inches (203 mm) into the block units. The geogrid layers must be pulled taut and anchored to the compacted backfill prior to backfilling over the geogrid.

2.4 Structural Analysis:

Structural calculations must be submitted to the building official for each wall system. The analysis must be based on accepted engineering principles and the Allan Block Retaining Walls Design Manual. All contact surfaces must be in compression. The compression stress is limited to a maximum of 100 psi (690 kPa). A net resultant tension force is prohibited throughout the retaining wall. The shear resistance of the block lip is 645 pounds per lineal foot of block width (962 kg/m).

2.5 Geogrid:

To increase the performance of the Allan Block Retaining Wall System, various grid materials are available. To aid in the selection of the grid material, Tables 2 through 10 provide information needed for design.

2.5.1 Miragrid: Miragrid geogrid grades 3XT, 5XT, 7XT, 8XT, 9XT, and 10XT produced by Mirafi Inc., are compatible with the Allan Block Retaining Wall System. The grid consists of polyester yarns with acrylic latex coating, formed with a grid-shaped opening. Prolonged exposure of the grid to sunlight must be avoided. The grid is installed by placing it over the block and pulling it tight. The roll or warp direction is the direction of the main reinforcement. After unrolling, the geogrid is tensioned by hand until taut, free of wrinkles and flat. Adjacent rolls are overlapped a minimum of 4 inches. Structural design is in accordance with Section 2.4 of this report. Applicable design properties are indicated in Tables 3-A, 3-B, and 10. Pullout resistance (P), in lb./ft., is a function of normal load (N), in lb./ft., due to the weight of superimposed units. Miragrid geogrid is stored at temperatures above –10°F (–23°C), and contact with mud, wet cement, epoxy or other adhesive materials must be avoided.

2.5.2 Tensar: Tensar geogrid grades UX1400HP and UX1500HP, produced by Contech Construction Products Inc., are compatible with the Allan Block Retaining Wall System. The grid consists of high-density polyethylene mesh openings (ribs/junctions). The grid is installed by placing it over the block and pulling it tight. The roll or warp direction is the direction of the main reinforcement. After unrolling, the geogrid is tensioned by hand until taut, free of wrinkles and flat. Adjacent rolls are overlapped a minimum of 4 inches (102 mm). Structural design is in accordance with Section 2.4 of this report. Applicable design properties are indicated in Tables 4-A, 4-B, and 10. Pullout resistance (*P*), in lb./ft., is a function of normal load (*N*), in lb./ft., due to the weight of superimposed units. Tensar geogrid is stored at temperatures above –10°F (–23°C), and contact with mud, wet cement, epoxy or other adhesive materials must be avoided.

2.5.3 Huesker: Huesker geogrid grades Fortrac 20/9-20, 35/20-20, 55/30-20 and 80/30-20, produced by Huesker Corporation, are compatible with the Allan Block Retaining Wall System. The grid consists of polyester yarns woven into an interlocking pattern and coated with PVC. The grid is installed by placing it over the block and pulling it tight. The roll or warp direction is the direction of the main reinforcement. After unrolling, the geogrid is tensioned by hand until taut, free of wrinkles and flat. Adjacent rolls are overlapped a minimum of 4 inches (102 mm). Structural design is in accordance with Section 2.4. Applicable design properties are indicated in Tables 5-A, 5-B, and 10. Pullout resistance (P), in lb./ft., is a function of normal load (N), in lb./ft., due to the weight of superimposed units. Huesker geogrid is stored at temperatures above –10°F (–23°C), and contact with mud, wet cement, epoxy or other adhesive materials must be avoided. The grid material is prone to ultraviolet degradation.

2.5.4 Strata: Strata geogrid grades 300 and 500, produced by Strata Systems, Inc., is compatible with the Allan Block Retaining Wall System. The grid consists of polyester yarns woven into an interlocking pattern and coated with PVC. The grid is installed by placing it over the block and pulling it tight. The roll or warp direction is the direction of the main reinforcement. After unrolling, the geogrid is tensioned by hand until taut, free of wrinkles and flat. Adjacent rolls are overlapped a minimum of 4 inches. Structural design is in accordance with Section 2.4. Applicable design properties are indicated in Tables 6-A, 6-B, and 10. Pullout resistance (*P*), in lb./ft., is a function of normal load (*N*), in lb./ft., due to the weight of superimposed units. Strata geogrid is stored at temperatures above –10°F (–23°C), and contact with mud, wet cement, epoxy or other adhesive materials must be avoided. The grid material is prone to ultraviolet degradation.

2.5.5 AMOCO: Amoco geotextile grade PX-2044, produced by Amoco Fabrics and Fiber Company, is compatible with the Allan Block Retaining Wall System. The geotextile consists of polypropylene yarn woven into a solid matt fabric with no spacing between warp and fill yarns. The PX-2044 is installed by placing it over the block and pulling it tight. The roll or warp direction is the direction of the main reinforcement. After rolling, the geogrid is tensioned by hand until taut, free of wrinkles and flat. Adjacent rolls are overlapped a minimum of 4 inches. Structural design is in accordance with Section 2.4 of this report. Applicable design properties are described in Tables 7-A, 7-B, and 10. Pullout resistance (*P*), in lb./ft., is a function of normal load (*N*), in lb./ft., due to the weight of

superimposed units. Amoco geotextile is stored at temperatures above –10°F (–23°C), and contact with mud, wet cement, epoxy or other adhesive materials must be avoided. The PX-2044 material is prone to ultraviolet degradation.

2.5.6 Synteen: Synteen grades SF35, SF55, and SF80, produced by Luckenhaus Inc., are compatible with the Allan Block Retaining Wall System. The grid consists of polyester yarns woven into an interlocking pattern and coated with PVC. The grid is installed by pulling it over the block and pulling it tight. The roll or wrap direction is the direction of the main reinforcement. After unrolling, the grid is tensioned by hand until taut, free of wrinkles and flat. Adjacent rolls are to be butted up tight and need not be overlapped. Structural design shall be in accordance with Section 2.4. Applicable design properties are indicated in Tables 8-A, 8-B, and 10. Pullout resistance (P), in lb./ft., is a function of normal load (N), in lb./ft., due to the weight of superimposed units. Raugrid is stored at a temperature above -10°F (-23°C), and contact with mud, wet cement, epoxy or other adhesive materials must be avoided. The grid material is prone to ultraviolet degradation.

2.5.7 Raugrid: Raugrid Grades 2/3-30, 3/3-30, 4/2-15 and 6/3-15 are produced by Luckenhaus Inc. and are compatible with the Allan Block Retaining Wall System. The grid consists of polyester yarns woven into an interlocking pattern and coated with PVC. The grid is installed by pulling it over the block and pulling it tight. The roll or wrap direction is the direction of the main reinforcement. After unrolling, the grid is tensioned by hand until taut, free of wrinkles and flat. Adjacent rolls are to be butted up tight and need not be overlapped. Structural design shall be in accordance with Section 2.4. Applicable design properties are indicated in Tables 9-A, 9-8, and 10. Pullout resistance (P), in lb./ft., is a function of normal load (N), in lb./ft., due to the weight of superimposed units. Raugrid is stored at a temperature above -10°F (-23°C), and contact with mud, wet cement, epoxy or other adhesive materials must be avoided. The grid material is prone to ultraviolet degradation.

2.6 Identification:

Each pallet of blocks is identified with the manufacturer's name and address, product name, type of unit and ER-5087. The geogrids are identified by a certificate of compliance with the geogrid manufacturer's name and address, the name of the product, and the product designation, with the certificate accompanying each shipment.

3.0 EVIDENCE SUBMITTED

Reports of tests on geogrid strength, geogrid durability, geogrid soil interaction, geogrid pullout, and unit shear; engineering calculations; installation instructions; and quality control manuals.

4.0 FINDINGS

That the Allan Block Retaining Wall System described in this report complies with the 1997 *Uniform Building Code*™ (UBC), subject to the following conditions:

4.1 The system is designed and installed in accordance with this report; the Federal Highway Administration report "Design and Construction Guidelines for Reinforced Soil Structures, Volume I" (FHWA); the Allan Block Retaining Walls Design Manual; manufacturer's instructions and accepted engineering principles.

4.2 Calculations and plans justifying the design must be submitted to and approved by the building official.

4.3 Copies of the FHWA and the Allan Block Retaining Walls Design Manual must be furnished to the building official.

4.4 A foundation investigation, in accordance with Section 1804 of the UBC, is provided for each project site.

4.5 Special inspection is required for block placement, backfill and geogrid installation in accordance with Section 1701 of the code and pages 20 and 21 of the Allan Block Design Manual (AB1001-893-1993).

This report is subject to re-examination in two years.

TABLE 1—MAXIMUM WALL HEIGHTS (IN FEET) FOR UNREINFORCED ALLAN BLOCK WALLS[1,2]

		CONDITIONS ABOVE RETAINING WALL						
SOIL TYPE	**0**	**Level Slope**	**5-to-1 Slope**	**4-to-1 Slope**	**3-to-1 Slope**	**2-to-1 Slope**	**150 psf Surcharge**	**250 psf Surcharge**
Firm clay	26 degrees	3.5	3.0	2.5	2.0	1.5	2.5	2.0
Silty clay	28 degrees	4.0	3.5	3.0	2.5	2.0	3.0	2.3
Mixed silts	30 degrees	4.5	4.0	3.5	3.0	2.5	3.5	2.5
Silty sand	32 degrees	5.0	4.5	4.0	3.5	3.0	4.0	3.0
Clean sand	34 degrees	5.5	5.0	4.5	4.0	3.5	4.5	3.5

For **SI:** 1 foot = 304.8 mm, 1 psf = 47.88 Pa.

[1]Seismic restrictions not included.
[2]Twelve degrees from vertical.

TABLE 2—GEOGRID MATERIAL GRADES

LIGHT GRADE	MEDIUM GRADE	HEAVY GRADE
Fortrac 20/9-20	Fortrac 35/29-20	Fortrac 80/30-20
Miragrid 3XT	Fortrac 55/30-20	Miragrid 8XT
PX-2044	Miragrid 5XT	Miragrid 10X7
Raugrid 2/3-30	Miragrid 7XT	UX 1500HP
Raugrid 3/3-20	UX 1400HP	Synteen SF 80
Synteen SF 35	Raugrid 4/2-15	STRATA 500
—	Raugrid 6/3-15	—
—	Synteen SF 55	—
—	STRATA 300	—

TABLE 3-A—MIRAGRID PROPERTIES

GRADE	WEIGHT ($oz./yd^2$)	LONG-TERM ALLOWABLE TENSION LOAD, MD (lbs./ft.)
Miragrid 3XT	6.0	1328
Miragrid 5XT	6.0	1733
Miragrid 7XT	6.8	2157
Miragrid 8XT	8.5	3089
Miragrid 10XT	12.5	4116

For **SI:** 1 lb. = 0.45 kg, 1 $oz./yd^2$ = 33.9 g/m^2.

TABLE 3-B—MIRAGRID/SHEAR STRESS INTERACTION

SOIL CLASS	COEFFICIENT
GW	0.9
SW and SP	0.8
MH	0.7

TABLE 4-A—TENSAR PROPERTIES

GRADE	THICKNESS RIBS/JUNCTIONS (inches)	LONG-TERM ALLOWABLE TENSION LOAD, MD (lb.)
UX1400HP	0.03/0.11	1,525
UX1500HP	0.05/0.17	2,525

TABLE 4-B—TENSAR/SHEAR STRESS INTERACTION

SOIL CLASS	COEFFICIENT
GW and GM	1.00
SW and SM	0.90
SC and ML	0.80
CL	0.70

TABLE 5-A—HUESKER PROPERTIES

GRADE	WEIGHT ($oz./yd^2$)	LONG-TERM ALLOWABLE TENSION LOAD, MD (lbs/ft)
Fortrac 20/13-20	5	729
Fortrac 35/20-20	7	1207
Fortrac 55/30-20	9	1767
Fortrac 80/30-20	14	2570

For **SI:** 1 lb. = 0.45 kg, 1 $oz./yd^2$ = 33.9 g/m^2.

TABLE 5-B—HUESKER/SHEAR STRESS INTERACTION

SOIL CLASS	COEFFICIENT
GW and GM	1.00
SW and SM	0.90
SC and ML	0.80
CL	0.70

TABLE 6-A—STRATAGRID PROPERTIES

GRADE	WEIGHT ($oz./yd^2$)	LONG-TERM ALLOWABLE TENSION LOAD, MD (lb.)
STRATAGRID 300	5.8	730
STRATAGRID 500	10	1,100

For **SI:** 1 lb. = 0.45 kg, 1 $oz./yd.^2$ = 33.9 g/m^2.

TABLE 6-B—STRATAGRID/SHEAR STRESS INTERACTION

SOIL CLASS	COEFFICIENT
GW and GM	0.90
SW and SM	0.80
SC and ML	0.70
CL	0.60

TABLE 7-A—AMOCO PROPERTIES

GRADE	WEIGHT ($oz./yd^2$)	LONG-TERM ALLOWABLE TENSION LOAD, MD (lb.)
PX-2044	13	244

For **SI:** 1 lb. = 0.45 kg, 1 $oz./yd.^2$ = 33.9 g/m^2.

TABLE 7-B—AMOCO/SHEAR STRESS INTERACTION

SOIL CLASS	COEFFICIENT
GW and GM	0.84
SW and SM	0.74
SC, ML and CL	0.67

TABLE 8-A—SYNTEEN PROPERTIES

GRADE	WEIGHT ($oz./yd^2$)	LONG-TERM ALLOWABLE TENSION LOAD, MD (lbs/ft)
Synteen SF 35	6.27	1106
Synteen SF 55	7.37	1600
Synteen SF 80	8.63	2326

For **SI:** 1 lb. = 0.45 kg, 1 $oz./yd.^2$ = 33.9 g/m^2.

TABLE 8-B—SYNTEEN/SHEAR STRESS INTERACTION

SOIL CLASS	COEFFICIENT
GW	0.75
SW and SP	0.80
MH	0.71

TABLE 9-A—RAUGRID PROPERTIES

GRADE	WEIGHT ($oz./yd^2$)	LONG-TERM ALLOWABLE TENSION LOAD, MD (lbs/ft)
Raugrid 2/3-30	6.8	737
Raugrid 3/3-20	7.4	1120
Raugrid 4/2-15	73.7	1426
Raugrid 6/3-15	10.4	2077

For **SI:** 1 lb. = 0.45 kg, 1 $oz./yd.^2$ = 33.9 g/m^2.

TABLE 9-B—RAUGRID/SHEAR STRESS INTERACTION

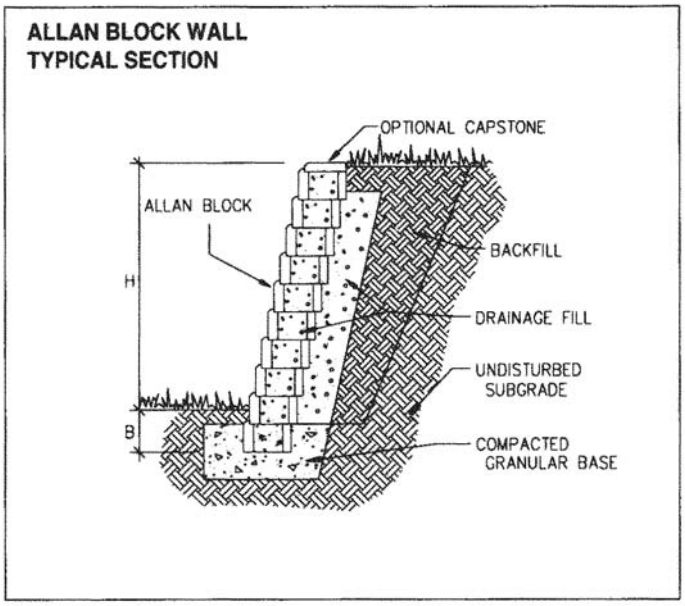
SOIL CLASS	COEFFICIENT
GW	0.90
SW and SP	0.90
MH	0.80

TABLE 10—FACING CONNECTION CAPACITY[1,2]

GEOSYNTHETIC REINFORCEMENT		PULLOUT RESISTANCE, $P_{conn@3/4}$ (lbs./ft.)	MAXIMUM PULLOUT RESISTANCE, P_{max} (lbs./ft.)
Brand Name	Grade		
Amoco	PX-2044	= 80 + N × 0.875	100
Fortrac	20/9-20	= 551 + N tan 6°	786
	35/20-20	= 1,056 + N tan 9°	1,427
	55/30-20	= 834 + N tan 31°, when $N \leq$ 1,486 lbs/ft	1,776
		= 1,439 + N tan 13°, when N > 1,486 lbs/ft	1,964
	80/30-20	= 472 + N tan 44°, when $N \leq$ 1,115 lbs/ft	1,545
		= 1,147 + N tan 20°, when N > 1,115 lbs/ft	2,268
Mirafi	3XT	= 551 + N tan 22°	1,490
	5XT	= 667 + N tan 18°	1,355
	7XT	= 546 + N tan 21°	1,773
	8XT	= 1,007 + N tan 32°	2,460
	10XT	= 598 + N tan 33°	2,482
Raugrid	2/3-30	= 340 + N tan 24°	638
	3/3-30	= 208 + N tan 14°	40
	4/2-15	= 620 + N tan 16°	955
	6/3-15	= 304 + N tan 14°	755
Strata	300	= 165 + N × 0.463	1,754
	500	= 300 + N × 0.241	2,085
Synteen	SF35	= 578 + N tan 15°	1,173
	SF55	= 799 + N tan 22°	1,754
	SF80	= 762 + N tan 26°, when $N \leq$ 1,816 lbs/ft	1,670
		= 1,226 + N tan 14°, when N > 1,816 lbs/ft	1,964
Tensar	UX1400HP	= 196 + N × 0.645	2,286
	UX1500HP	= 282 + N × 0.646	2,812

For **SI:** 1 lb./ft. = 14.6 N/m, 1 lb. = 4.45 N, 1 inch = 25.4 mm.

[1]Where:
$P_{conn@3/4}$ = Serviceability connection strength established at $^3/_4$-inch deformation.
Max P_{max} = Maximum allowable serviceability connection strength established at $^3/_4$-inch deformation.
N = The weight of the stacked SRW units (lbs/ft).
[2]Tabulated values are typical. Actual values used in design must be approved by the soils engineer of record and the building official.

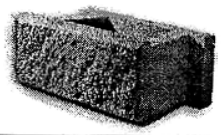
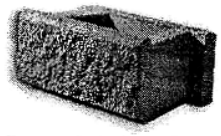


GENERAL NOTES

- Coverage – 1 sqft/block (929 cm^2/block)
- Set Back
  0.375 inch/block (9.5 mm/block) – 3 degrees from vertical
  1.5 inches/block (38 mm/block) – 12 degrees from vertical

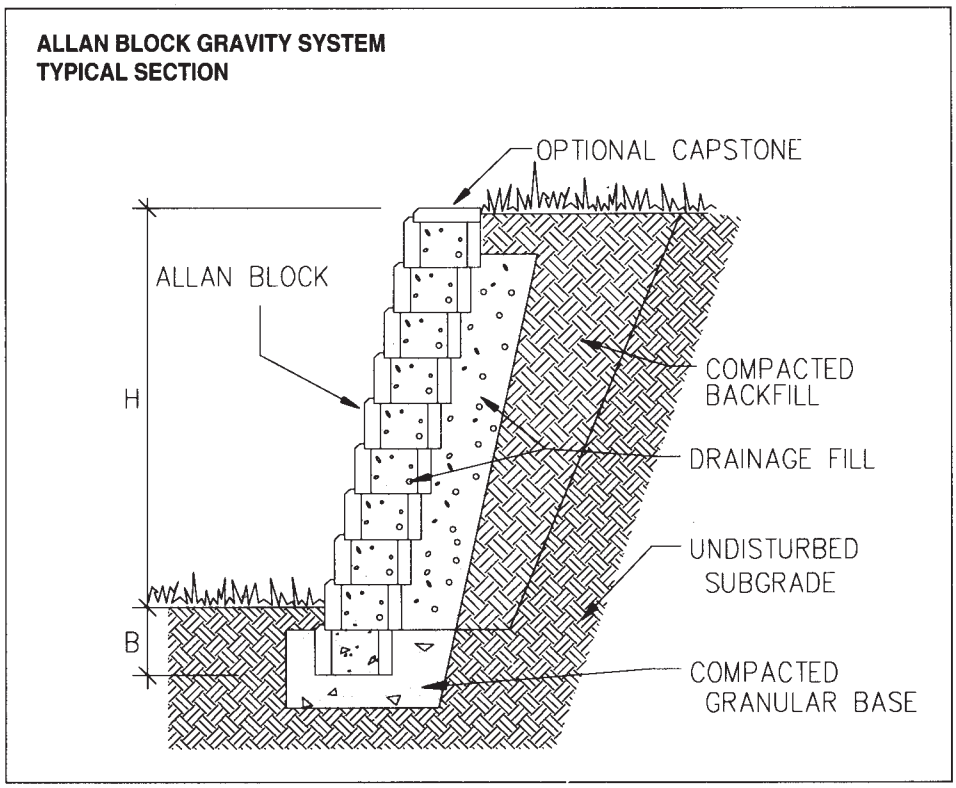
FIGURE 1

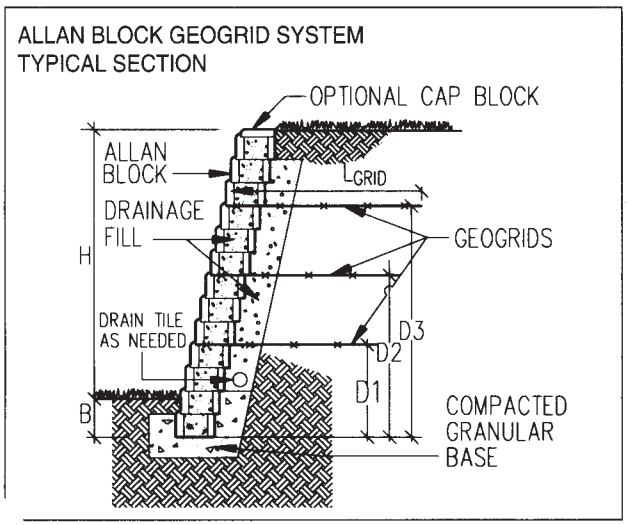
All dimensions are in inches unless otherwise noted.

Block Type	Dimensions (H x D x W)	Lip Depth	Notch Depth
AB STONES 	7.625 x 11.75 x 17.625 73 +/- 2 lbs	2.1	0.5
AB CLASSIC 	7.625 x 11.75 x 17.625 73 +/- 2 lbs	2.1	1.2
AB THREE 	7.625 x 11.75 x 17.625 73 +/- 2 lbs	1.7	1.2
AB ROCKS 	7.625 x 11.75 x 17.625 69 +/- 2 lbs	2.6	2

For **SI:** 1 inch = 25.4 mm, 1 lb. = 0.45 kg.

FIGURE 2—ALLAN BLOCK RETAINING WALL DETAILS





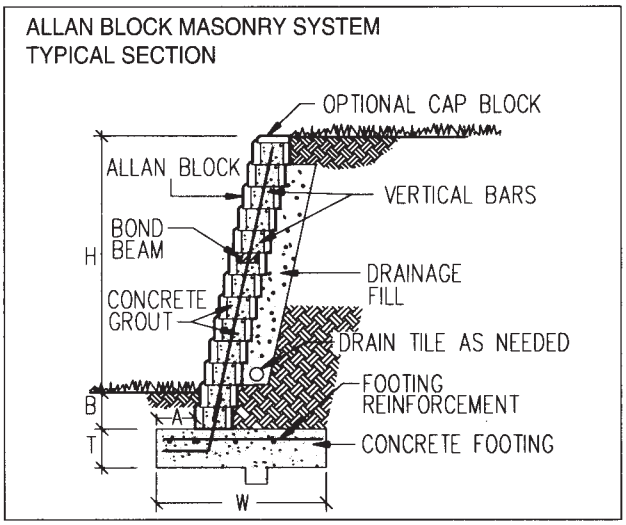


FIGURE 3—TYPICAL SECTIONS