GSE-B-2-2 Form	PREPARED BY Baljit S. Nanda CHECKED BY R.S. Chhina APPROVED BY M.C. Hendrickson REV. 0 DATE 5/10/84	SH. 1 CONT. ON SH. 2
MR No. FC-81-180		OMAHA PUBLIC POWER DISTRICT GENERATING STATION ENGINEERING

MASONRY UNIT WALL

FORT CALHOUN POWER STATION

MR-FC-81-180

CLIENT

Omaha Public Power District (OPPD)

ANALYSIS TITLE

Block Pull Out Evaluation of Masonry Walls at Fort Calhoun Station

AUTHOR IDENTIFICATION

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PURPOSE

The Nuclear Regulatory Commission asked the District to perform Block Pull Out Calculations during a seismic event (Ref. #1, Item 4) to consider whether the attachments on the wall could cause a block pull out during a seismic event.

METHOD OF ANALYSIS

Seismic loads caused by the attachment on a wall will be calculated and compared against the block pull out capacity of a block at that location.

INPUT INFORMATION - FURNISHED BY CLIENT

1. Updated Safety Analysis Report (USAR), Appendix F, "Classification of Structures and Equipment and Seismic Criteria."
2. Location of Attachments on Masonry Walls.
3. Cable Tray Seismic Analysis by Gibbs, Hill, Durham & Richardson (dated 6/30/71).

ASSUMPTIONS

1. Walls are unreinforced hollow masonry unit walls.
2. Mortar shear strength is compatible with the shear strength of concrete block.
3. Concrete block shell will fail before the failure of attachment anchors (Case I).
4. Pull out force is evenly transferred to the perimeter of concrete block (Case II) with possible block pull out.
5. No through bolts are installed at any location.
6. Anchor embedment length meets the manufacturer's requirements and will develop full strength.

REFERENCE DOCUMENTS

1. Letter from NRC to OPPD, dated February 6, 1984, "Request for Additional Information, Masonry Wall Design IE Bulletin 80-11."
2. Updated Safety Analysis Report (USAR) Fort Calhoun Station Unit No. 1, Appendix F, "Classification of Structures and Equipment and Seismic Criteria."
3. ACI 531-79, Building Code Requirements for Concrete Masonry Structures.
4. Technical Specification No. 14 - Masonry, Contract #764, Fort Calhoun Station Unit No. 1.
5. ASTM Specifications for Concrete Masonry Units.
6. Cable Tray Seismic Analysis by Gibbs, Hill, Durham & Richardson, (dated 6/30/71).
7. Specification for the Design and Construction of Load-Bearing Concrete Masonry, 1979 - National Concrete Masonry Association.
8. Dynamic Analysis of Masonry Walls, Calculated by B. S. Nanda.
9. Reinforced Masonry Engineering Hand Book, Fourth Edition, by James Amrhein.

REFERENCE DRAWINGS

1. Gibbs, Hill, Durham & Richardson Drwg. 11405-A-5
2. Gibbs, Hill, Durham & Richardson Drwg. 11405-A-6
3. Gibbs, Hill, Durham & Richardson Drwg. 11405-A-7
4. Gibbs, Hill, Durham & Richardson Drwg. 11405-A-8

MATERIALS OF CONSTRUCTION - (Ref. #4)

Existing Masonry Walls have the following properties:

a.	Concrete Masonry Units	- ASTM C90, Type P-II
b.	Mortar	- ASTM C270, Type N
c.	Vertical Joint	- Running Bond
d.	Installation	- Plumb true to lines, full mortar joints, 3/8" joints, 40°F ambient temperature

ANALYSIS APPROACH

1. Seismic loads on the wall attachment anchors will be calculated based on acceleration values from floor response spectras provided by the Omaha Public Power District.

2. Block resistance against pull out will be calculated based on the following cases:

   Case I: Blocks are not grouted and wall attachment anchors are supported by the block shell only.

   (This case may cause local shell failure only)

   Case II: Blocks are solid grouted and anchor load is transferred evenly to the perimeter of the block.

   (This case may cause a block pull out)

3. Block pull out forces will be compared against the block resistance to conclude that block pull out is possible or not.

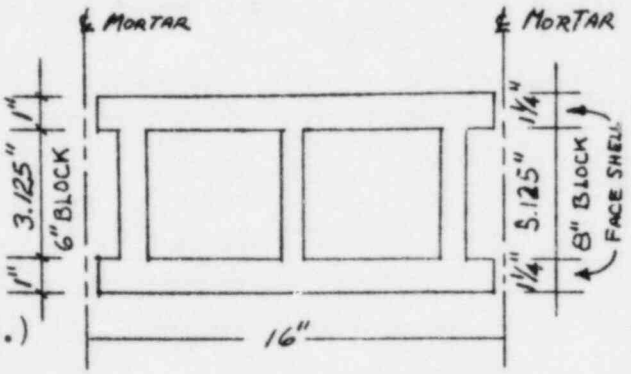
ALLOWABLE STRESSES

1. Allowable Shear Strength of Type "N" Mortar = 23 psi (Ref. #7).
2. Coefficient of Friction = 0.7 (Ref. #9).

PROPERTIES OF CONCRETE BLOCK

Block Area Contributing to Bond:

(Consider ℄ to ℄ of Mortar Joint)



8" Block:

Side Shell Area = 2(2 x 1.25" x 8" Ht.)
= 40 IN^2

Top & Bottom Area = 2(2 x 16" x 1.25")
= 80 IN^2

Total Area = 40 + 80 = 120 IN^2
(Ignore Web Area)

6" Block

Side Shell Area = 2(2 x 1.00" x 8" Ht.)
= 32 IN^2

Top & Bottom Area = 2(2 x 16" x 1.00")
= 64 IN^2

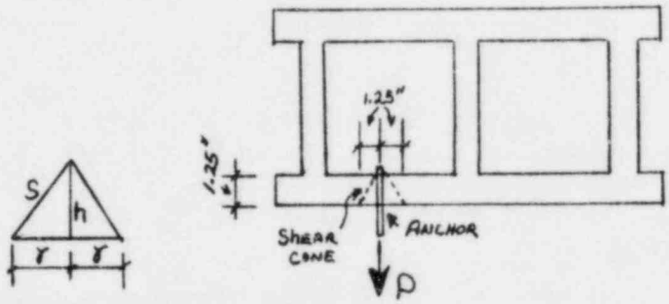
Total Area = 32 + 64 = 96.0 IN^2
(Ignore Web Area)

RESISTANCE AGAINST BLOCK PULL OUT

Case I - Unreinforced Masonry Block:

Allow Shear Stress = 23 psi

Cone Surface Area = $\pi r S$



8" Block: $h = r = 1.25$, $S = \sqrt{h^2 + r^2} = \sqrt{1.25^2 + 1.25^2} = 1.768"$

Area = π x 1.25 x 1.768 = 6.94 IN^2

P = Pull Out Force = 23 x 6.94 = 159.6#

6" Block: $h = r = 1.0$, $S = \sqrt{h^2 + r^2} = \sqrt{2} = 1.414$

Area = π x 1.0 x 1.414 = 4.44 IN^2

P = Pull Out Force = 23 x 4.44 = 102.12#

Case II - Unreinforced - Grouted Masonry:

Resisting Forces:

Total Resisting Force = Shear Bond Resistance & Shear Frictional Forces due to weight wall above block course.

1. Shear Bond Resistance:

   a. 8" Block = 23 psi x 120 IN^2 = 2760#
   b. 6" Block = 23 psi x 96.0 IN^2 = 2208#

2. Shear Frictional Force:

   This force depends on the height of wall above the subject block course and will be calculated for individual cases (if needed).

Seismic Forces Causing Block Pull Out:

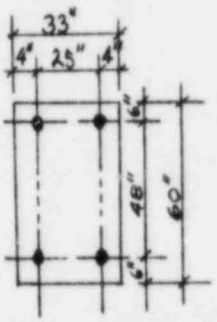
1. Factors Causing Block Pull Out:

   a. Total number of anchors used for attachment
   b. Number of anchors in one block
   c. Weight of attachment
   d. Elevation of anchor
   e. Thickness of wall

CONTROL ROOM - SOUTH WALL OF COMPUTER ROOM, LOOKING NORTH (8" WALL)

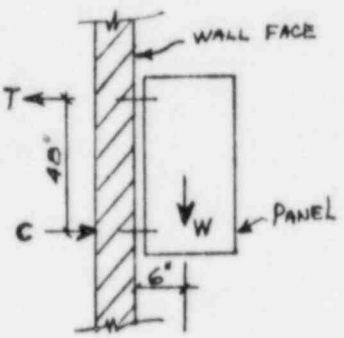
Attachment: Electrical Distribution Panel (480V)

Data:



Panel size = 60" x 33" x 9"
Panel Wt. = 500# (Approx.)
No. of Anchors = 4-1/2" Ø
Max. No. of Anchors/Block = 1
Panel is design as rigid panel
Top anchor bolt El. = 1053'-0"
Top of wall El. = 1065'-6"

Calculations:



Panel is designed as rigid panel so acceleration value from Fig. F-16 (Ref. #2).

= 0.329g x 1.5 (conservative)
= 0.494g

Acceleration value from dynamic analysis of masonry wall = 1.611 g (Calculation by B. Nanda)

Assume Horiz. Acceleration = 2.0g
Vert. Acceleration = 2/3 x 2.0g = 1.33g

Horizontal Seismic Load = 500# x 2.0 = 1000#
Vertical Seismic Load = 500# x 1.33g = 665#

$$\text{Horizontal Force @ Top Anchor} = 1000/4 + \left[(665\#+500\#) \times \frac{6}{48}\right] \times 1/2$$

$$= 322.8\#$$

Resistance Capacity of 8" Block Against Pull Out (Without Shear Friction Resistance) = 2760# > 322.8#

BLOCK PULL OUT IS NOT POSSIBLE

BATTERY ROOM - NORTH WALL LOOKING SOUTH (8" WALL)

Attachment: Cable Tray Support (Horizontal)

Cable Tray Data:

Size = 24"

Span = 16.7' (Max) (Ref. #6) Page 61.

Cable Tray with Cables = 56.8#/Ft.

NOTE: Cable trays have two support systems:

a. Hanger rod and unistruts are designed to carry dead load of cable trays and vertical seismic load.

b. Horizontal supports are designed to resist horizontal seismic loads.

Seismic Load:

Dead load of cable tray on support = 56.8#/'x 16.7'
= 948.6#

Natural Frequency of Cable Tray = Rigid Zone For L = 16.7' (Ref. #6)

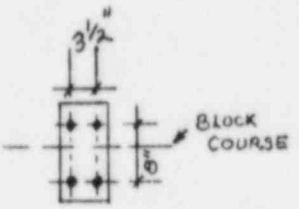
From Fig. F-16 (Ref. #2), Response of Equipment located in Aux. Building (Mass #4) acceleration for rigid zone = 0.329g x 1.5 = 0.494g

Ref: (Dynamic Analysis of Masonry Walls)

Acceleration from Dynamic Analysis of Wall = 0.916g ≈1.0g (conservative)

Horizontal Seismic Load = 948.6 x 1.0g = 948.6#

No. of bolts on support = 4
Assume 2 bolts per block
Block Pull Out Force = $\frac{948.6 \times 2}{4}$ = 474.3#



Resistance of 8" Block Against Pull Out
(Without Shear Friction) = 2760# > 474.3#

SO DURING A SEISMIC EVENT BLOCK WILL NOT PULL OUT!

AUXILIARY BUILDING

North wall of corridor between column line 7a and 7b - looking north (6" wall).

Attachment: Cable Tray Supports (Horizontal Only)

Cable Tray Data:

No. of stacked cable trays = 3

Cable tray size = 24"

Wt. of cable tray full of cable = 56.8#/Ft. (Ref. #6)

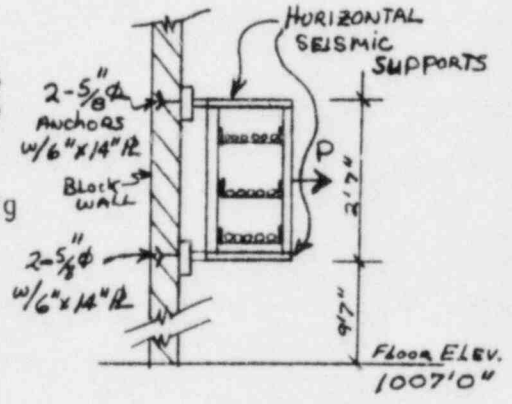
Span of cable trays supports = 16.7'

NOTE: Horizontal supports are designed to support horizontal loads only. Vertical dead load and seismic load are supported by unistrut and hanger rod system.

Block Pull Out Load:

Dead load of cable trays = 3 x (56.8#/Ft. x 16.7')

= 2845.7#



Assuming cable trays and supports are designed as rigid (Ref. #6), acceleration for rigid zone Fig. F-16 (Ref. #2) = 0.329 x 1.5 = 0.496

Acceleration value for wall from dynamic analysis = 1.492g

Using conservative value for Horizontal Seismic Load

= 2845.7# x 1.492g

= 4245.8#

Assuming load is resisted by 2 leg supports, load per support = 4245.8/2 = 2122.9#

2123#

Assuming that both bolts at top are anchored in the same block, block pull out force = 2123#

Resistance of 6" block pull out (Without Shear Frictional Resistance) = 2208# > 2123#

BLOCK PULL OUT IS NOT POSSIBLE

CONCLUSION

The analysis shows that block pull out will not occur in a seismic event. The analysis performed is conservative because of the following:

1. In Case II, even though the block cells were considered to be grouted, the shear resistance of grout area was neglected.

2. Shear frictional resistance due to weight of block wall above the block course was neglected.

3. Web area of the shell was not considered.