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AUTH.NAME AUTHOR AFFILIATION
GIESLER,C.W. Wisconsin Public Service Corp.
RECIP.NAME RECIPIENT AFFILIATION
VARGA,S.A. Operating Reactors Branch 1

SUBJECT: Forwards addl info in response to IE Bulletin 80-11 re seismic qualification of masonry walls.W/23 aperture cards. Aperture cards are available in PDR.

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NRC-83-93

# WISCONSIN PUBLIC SERVICE CORPORATION

P.O. Box 1200, Green Bay, Wisconsin 54305

April 29, 1983

Director of Nuclear Reactor Regulation
Attention: Mr. S. A. Varga, Chief
Operating Reactors Branch No. 1
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Varga:

Docket 50-305
Operating License DPR-43
Kewaunee Nuclear Power Plant
IE Bulletin 80-11; Seismic Qualification of Masonry Walls

References: See Attachment 1

Reference 10 on the attached list is a request for additional information concerning the seismic qualification of masonry walls at the Kewaunee Plant.

The request consists of eleven questions concerning past design and construction practices. Some of the requests require comparison of the design to the Branch Technical Position (BTP) for Masonry Wall Design and justification of differences. We have compiled answers to your questions based on a sample of 5 of 16 safety-related wall areas. A list of safety-related wall areas is enclosed as attachment 2.

On March 14 and 15, 1983 an announced inspection of safety-related masonry walls was conducted by a representative of NRC Region III. During the exit interview the inspector, Mr. John Norton, requested that we submit copies of design drawings for your review. These drawings are reproduced on aperature cards and are submitted as enclosure 1. A listing of the cards is included as attachment 3.

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The response to the request for information is enclosed as attachment 4. The numbering is consistent with the original request.

Very truly yours,

C. W. Giesler
Vice President - Nuclear Power

js

Attach.

cc - Mr. J. G. Keppler
Mr. Robert Nelson, US NRC
Director, Office of Inspection & Enforcement, US NRC

Attachment 4
April 29, 1983

WISCONSIN PUBLIC SERVICE CORPORATION
KEWAUNEE NUCLEAR POWER PLANT
MASONRY WALLS - IE BULLETIN 80-11

Response to Request for Additional Information
NRC Letter of February 22, 1983

This report is in response to the additional information and clarifications requested by the NRC regarding the safety related masonry block walls at the Kewaunee Plant. The informations provided in this report are verified for only the masonry walls noted below.

1) Walls surrounding the diesel generator day tanks - one for each diesel.

2) Walls surrounding the NSSS liquid filter room.

3) Wall between the maintenance material storage room and the steam generator blowdown heat exchanger area.

INQUIRY 1

With respect to loads and load combinations, the Licensee's submittals (2-6) mention only that the primary loads imposed on the masonry walls are seismic loads. Indicate the load combinations used in the reevaluation of masonry walls at the Kewaunee Plant and justify the difference between these and the load combinations specified for Class I structures in Appendix B, Table B-6.1, of the Final Safety Analysis Report (FSAR).

RESPONSE

The loads and load combinations used for the reevaluation of the masonry block walls are the same as those specified in Appendix B table B-6.1 of the Kewaunee Nuclear Power Plant FSAR. These load combinations are reproduced as follows:

1) Normal Operating (Dead + Live + Wind + Snow)

2) Operational Basis Earthquake (OBE)
(Dead + Live + DBA + Snow + Greater of OBE or Wind)

3) Design Basis Earthquake (DBE)
(Dead + Live + Snow + DBA + DBE)

4) Tornado (Dead + Live + 300MPH Design Tornado + Tornado Missile, if any)

5) Other (In addition to above, jet forces, ice loads, pipe rupture loads, etc. whichever and wherever applicable)

The masonry walls for the Kewaunee Plant are interior partition walls and hence the loads such as Tornado, winds, and snow are clearly not applicable loads for the design of these walls. No major equipment or pressure piping is attached on these walls and, hence, the design basis accident loads are also not applicable.

The only loads that influence the design of the walls, therefore, are the self weights of the walls, minor piping, electrical conduits and/or boxes attached to these walls and the operating and design basis earthquake loads.

INQUIRY 2

Indicate how earthquake loads in three directions were considered in the analysis.

RESPONSE

The masonry walls of the Kewaunee Plant are designed for the following combinations of the seismic forces:

a) Floor spectral accelerations due to north south component of the earthquake combined with the accelerations due to the vertical component of the earthquake, and

b) Floor spectral accelerations due to east west component of the earthquake combined with the accelerations due to the vertical component of the earthquake.

The computed stresses for the walls for each direction of earthquake are added conservatively by the absolute sum method.

At the time of the original plant engineering, a small gap was deliberately kept between the masonry walls and the ceilings to permit interstory drift without inducing stresses in the partition walls.

Because of the very large stiffness of these walls in the vertical and the longitudinal directions, the stresses induced in the walls due to longitudinal and vertical directional earthquake are insignificant when compared with the stresses induced in the walls due to the seismic accelerations transverse to the walls.

INQUIRY 3

The Licensee does not mention tornado or impact loads in any of its submittals (2-6). Indicate whether any walls are subject to tornado or impact effects. If so, provide sample calculations for tornado and impact analysis.

RESPONSE - Inquiry 3

See response 1.

INQUIRY 4

The natural frequencies of masonry walls are subject to uncertainty due to variations in mass, materials, and other parameters. Indicate how these uncertainties were accounted for in the evaluation of the wall frequencies at the Kewaunee Plant.

RESPONSE

We have reviewed the original design of the masonry walls and we find several levels of conservatism built into the design which account for the uncertainties due to variations in mass, materials and other parameter. These levels are:

1) The damping used in the original design was .5% and 1% instead of 4% and 7% permitted by the SEB criteria.

2) The equations for the calculations of the frequency considered only one way action of the walls and hence treated the walls as being more flexible than they really are. In addition, the calculated frequencies for the one way systems were also 10 percent lower than the theoretical values.

The floor response spectrum curves for the Kewaunee Plant show that in the range of the computed frequencies for the walls, the design accelerations have consistently been higher with these assumptions. Therefore, adequate consideration has been given to these uncertainties.

INQUIRY 5

If allowable stresses were increased by 50%, as suggested by Reference 3, justify this increase for masonry shear, since the SEB criteria (7) allow an increase of only 30% under abnormal conditions. If any existing test data are used to justify this increase, the Licensee is required to discuss the applicability of these tests to the masonry walls at the Kewaunee Plant with particular emphasis on the following:

--boundary conditions
--nature of loads
--size of test walls
--type of masonry construction (block and mortar type, grouted or ungrouted)

The Licensee is also requested to identify the walls that would not be qualified if SEB criteria were used.

RESPONSE - Inquiry 5

A factor of 1.5 was used in the masonry wall design for the safe shutdown earthquake loads as per the FSAR of the Kewaunee Nuclear Power Plant.

The SEB criteria was issued since then (1981) and has arbitrarily established a factor as 1.3 for the masonry wall shear. The masonry walls reviewed for this response were found to be in compliance with the SEB criteria; therefore, we conclude that the design criteria used for KNPP are acceptable.

INQUIRY 6

Provide evidence that the contributions of higher modes of vibration are about 5% of the total response and need not be considered in the analysis, as stated in Reference 3, Section 2.0.

RESPONSE

As per Section 3.7.2 of the Standard Review Plan the response of the structure may be obtained by combining the response of each mode by the SRSS method. For the masonry walls analyzed as beams, this results in an insignificant contribution from the higher modes. The conclusion is illustrated below with the case of a uniformly loaded simple beam with a constant spectral acceleration.

The maximum bending moment for the beam is at its midspan. The even numbered modes do not contribute to this moment because of the midspan being the node point. Hence, the second and the fourth modes do not contribute to the midspan moment. The contribution of the third mode to the midspan bending moment for a constant spectral acceleration will be 1/27 times the bending moment due to the first mode. Similarly, contribution to the midspan bending moment due to the fifth mode will be 1/125 times that of the contribution of the first mode. Combining these moments with the SRSS method, and comparing the total with the contribution of the first mode the contribution due to higher modes are found to be

$$\left(\sqrt{1 + \left(\frac{1}{27}\right)^2 + \left(\frac{1}{125}\right)^2}\right) - 1$$

The above quantity is almost zero and hence is less than 5 percent of the total response.

For the design of the masonry walls, seismic loads due to the first mode were applied as uniform loads on the entire span. The midspan bending moment due to the uniform load is approximately 22% greater than for the loads corresponding to the fundamental mode shape. This increase exceeds the contributions of all the higher modes.

Similarly, it can be shown that the maximum shear in the beam, when all modes are considered, is less than the shear due to a uniform load on the beam when its intensity is based on the fundamental mode.

INQUIRY 7

Indicate if the construction practice at the Kewaunee Plant conformed to the provisions specified in ACI 531-79 (9) for the Special Inspection Category.

Also, indicate whether quality assurance/quality control information is available to support this categorization.

RESPONSE

The safety related masonry walls at Kewaunee were designed and constructed according to the provisions of the International Conference of Building Officials "Uniform Building Code" 1967 Edition. UBC-1967 has provisions to increase design stress levels as knowledge of material properties increased. The design of safety related masonry walls at Kewaunee took advantage of these increased stress levels.

Quality Control documentation is available to justify these increased stress levels. The documentation available applies to the rebar, mortar properties, block strength and dur-o-wall reinforcement. The quality control documentation methods in use at the time of construction consisted of recording deviations in construction rather than attesting to proper installation. We have reviewed a representative sample of the documentation and have found no deviations from design noted. A special non-destructive inspection will be conducted to confirm proper installation.

INQUIRY 8

Justify the use of 50 psi for allowable masonry shear stress (no shear reinforcement), as specified in Reference 3, Section 3.0. ACI 531-79 (9) lists allowable masonry shear for flexural members with no shear reinforcement as $1.1 \sqrt{f'_m}$ which is only 40 psi when $f'_m$ equals 1350 psi.

RESPONSE

The masonry walls were designed to meet the requirements of the 1967 Uniform Building Code which permitted shear stress of 50 psi.

We have now reevaluated the masonry walls identified on page 1 of this attachment. These walls meet ACI 531-79 criteria for masonry shear (i.e., 40 psi).

INQUIRY 9

None of the Licensee's submittals (2-6) mention whether the masonry walls at Kewaunee are stack or running bond. If any stack bond wall exist provide sample calculations of a typical stack bond wall.

RESPONSE

All safety related masonry walls at Kewaunee are running bond.

INQUIRY 10

Interstory drift effects were not mentioned in any of the Licensee's submittals (2-6). Indicate how interstory drift effects were considered in the analysis of masonry walls. Provide any criteria that may have been used to evaluate interstory drift effects and justify such use.

RESPONSE - INQUIRY 10

The masonry walls at the Kewaunee Plant are partition walls. When they span from floor to ceiling, a 3/4 inch gap was maintained between the top of the wall and the ceiling. The walls were simply supported by steel angles in the transverse direction.

The above boundary conditions permit the relative motions of the floors without inducing stresses in the walls.

INQUIRY 11

The ACI 531-79 Code (9) specifies that the minimum area of reinforcement in a wall in either direction, vertical or horizontal, shall be 0.0007 (0.07%) times the gross cross-sectional area of the wall and the minimum total area of steel, vertical and horizontal, shall not be less than 0.002 (0.2%) times the gross cross-sectional area. The License is requested to clarify whether the reinforced walls at the Kewaunee Plant meet these requirements.

RESPONSE

The masonry walls of the Kewaunee Plant are reinforced with the standard or extra heavy dur-o-wall reinforcement in the horizontal direction for temperature and shrinkage control. The area of the reinforcement is .02% of the gross cross-sectional area. The vertical reinforcement for these walls varies with the wall, the range being 0.15 percent to 0.46% of the gross cross-sectional area. Except for the walls around the material storage area, the total reinforcement for the walls exceed 0.2% of the gross cross-sectional area.

The subsection 11.3.2.1 of ACI 531-79 code states that 'Masonry may have reinforcement in the selected portions of walls as needed to resist tensile stresses with no requirement as to the percentage of reinforcement'. This section is similar to the section 24.19 (a) of UBC-1979 code which permits the masonry walls to be partially reinforced without minimum reinforcement requirements. Both ACI 531-79 and UBC-1979 are acceptable design codes per SEB criteria.

The masonry walls are designed with adequate reinforcements to carry the tension forces induced due to bending moments and are therefore acceptable.

Attachment 1
April 29, 1983

REFERENCES

1. IE Bulletin 80-11
Masonry Wall Design
NRC, 08-May-81

2. E. R. Mathews
Letter to J. G. Keppler, NRC. Subject: IE Bulletin 80-11, Masonry Wall Design - Kewaunee Plant
Wisconsin Public Service Corp., 09-Jul-80

3. E. R. Mathews and D. W. Sauer
Letter to G. Fiorelli, NRC. Subject: IE Bulletin 80-11, Masonry Wall Design - Kewaunee Nuclear Power Plant
Wisconsin Public Service Corp., 23-Sep-80

4. E. R. Mathews
Letter to J. G. Keppler, NRC. Subject: Response to IE Bulletin 80-11 for Kewaunee Plant
Wisconsin Public Service Corp., 08-Dec-80

5. E. R. Mathews
Letter to J. G. Keppler, NRC. Subject: Notarization of previous submittals regarding IE Bulletin 80-11
Wisconsin Public Service Corp., 23-Dec-80

6. E. R. Mathews
Letter to G. Fiorelli, NRC. Subject: Kewaunee Nuclear Power Plant - IE Bulletin 80-11
Wisconsin Public Service Corp., 26-Jan-81

7. SEB Criteria for Safety-Related Masonry Wall Evaluation
Structural Engineering Branch of the NRC, 00-Jul-81

8. Uniform Building Code
International Conference of Building Officials, 1979

9. Building Code Requirements for Concrete Masonry Structures
Detroit: American Concrete Institute, 1979
ACI 531-79 and ACI 531-R-79

10. Letter from S. A. Varga to C. W. Giesler dated February 22, 1983
Request for additional information.

Attachment 2
April 29, 1983

# SAFETY RELATED MASONRY WALLS

| BLDG | ELEV | ROOM - DESCRIPTION |
|---|---|---|
| ADMIN | 586'-0" | 1A DG FUEL OIL DAY TANKS ROOM |
| ADMIN | 586'-0" | 1B DG FUEL OIL DAY TANKS ROOM |
| ADMIN | 586'-0" | 1B DG ROOM BY DOOR #1 |
| ADMIN | 586'-0" | 1A DG ROOM BY DOOR #2 |
| ADMIN | 586'-0" | WALL DIVIDING DG ROOMS |
| AUX | 586'-0" | 4160V SWGR ROOM (EAST WALL) |
| AUX | 606'-0" | RELAY ROOM (SOUTH WALL) |
| AUX | 606'-0" | WORKING MATERIAL STORAGE ROOM |
| AUX | 606'-0" | FILTER ROOM |
| AUX | 626'-0" | CRD EQUIP. RM & COLD CHEM LAB |
| AUX | 626'-0" | STAIRWELL OUTSIDE OF I&C SHOP |
| AUX | 626'-0" | STAIRWELL (CONTROLLED SIDE-LOC G/5.5) |
| AUX | 642'-3" | DOCUMENT STORAGE ROOM |
| AUX | 642'-3" | HALLWAY OUTSIDE DOC. STOR. ROOM |
| AUX | 642'-3" | HALLWAY BY DOOR 199 & HOT I&C SHOP |
| CONT | 586'-0" | NEAR NORTH STAIRWAY |

Attachment 3
April 29, 1983

## DRAWING REFERENCES FOR

## SAFETY RELATED MASONRY WALLS

| Domestic Drawing Number | Revision | Title |
|---|---|---|
| A203 | V | General Arrangement, Turbine & Admin. Building - Basement Floor |
| A204 | AC | General Arrangement, Reactor & Auxiliary Building - Basement Floor |
| A206 | AC | General Arrangement, Reactor & Auxiliary Building - Mezzanine Floor |
| A208 | AH | General Arrangement, Reactor & Auxiliary Building - Operating Floor |
| A209 | P | General Arrangement, Reactor & Auxiliary Building - Miscellaneous Floor Plans |
| A240 | AA | Auxiliary Building - Mezzanine Floor Plan (Elevation 606'-0") |
| A242 | F | Auxiliary Building Intermediate Floor & Miscellaneous Details |
| A243 | N | Auxiliary Building Operating Floor Plan (Elevation 626'-0") |
| A245 | N | Auxiliary Building - Operating Floor Control Room Details |
| A246 | M | Auxiliary Building Masonry Reinforcing Details |
| A247 | J | Auxiliary Building Miscellaneous Plans & Details |
| S308 | S | Reinforced Concrete Wall Elevations Sections & Details |
| S309 | JK | Elevation 586'-0" Equipment Foundation Plan |
| S321 | V | Elevation 606'-0" Reinforced Concrete Floor Plan @ Mezzanine Floor |
| S324 | AB | Elevation 606'-0" Reinforced Concrete Wall Plan @ Mezzanine Floor |
| S328 | X | Elevation 626'-0" & 633'-6" Reinforced Concrete Floor Plan at Operating Floor |
| S335 | N | Embedded Plate & Insert for Hanger Supports under Slab @ 622'-3", 626', 633'-6", 642'-6", 649'-6" |

| | | |
|---|---|---|
| S336 | Q | Elevation 642'-3" & 649'-6" Reinforced Concrete Floor Plan Miscellaneous Floor |
| S350 | P | Elevation 606'-0" Reinforced Concrete Floor, Sections & Details |
| S509 | BB | Turbine & Administration Building Anchor Bolt Schedule & Miscellaneous Details |
| S510 | J | Administration Building Equipment Foundation Plan at Elevation 586'-0" Sections & Details |
| S235 | P | Reactor Building Concrete Plan @ El. 592'-0" Reinforcing |
| S236 | L | Reactor Building Concrete - Basement Floor - El. 592'-0" |