ATTACHMENT 3

May 23, 1983

R. E. GINNA NUCLEAR POWER PLANT

Evaluation of Concrete Code Changes
"Design Codes, Design Criteria, and Load Combinations"
Portion of USNRC SEP Topic III-7.B,

Prepared for

Rochester Gas and Electric Corporation

Originated By: J. M. Adamo / T. L. Moore

Reviewed By: J C Herr

Approved By: Chang Chen

Prepared by

Gilbert/Commonwealth

Reading, Pennsylvania

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

Since the early days of the nuclear power industry, there have been many changes and revisions to the licensing criteria, codes, and regulations for the design of commercial nuclear power plants. With this in mind, the United States Nuclear Regulatory Commission (NRC) initiated the Systematic Evaluation Program (SEP) to assess the safety of older plants in comparison to more recent criteria. The program envelopes a broad spectrum of safety issues, although not all issues are applicable to each plant. The various issues have been categorized into a number of "SEP Topics".

The R.E. Ginna Nuclear Power Plant is one of the plants included in the SEP, and, accordingly, the assessment of several safety issues was initiated. One such assessment related to Ginna has been designated SEP Topic III-7.B, "Design Codes, Design Criteria, and Load Combinations". The purpose of this topic is to assess the safety of Category I structures as a results of changes in design codes and load criteria. The assessment encompasses the review of both steel and concrete structures.

To accomplish this assessment, the NRC contracted Franklin Research Center (FRC) to evaluate the Ginna Station structures to current criteria. The results of that evaluation are contained in FRC's Technical Evaluation Report (TER) TER-C5257-322 (reference 1), which was issued as an attachment to the NRC's Safety Evaluation Report (SER) transmitted to RG&E by letter dated April 21, 1982 (reference 2). Both the SER and TER denote a number of criteria changes since the original plant design which had the potential to significantly impact margins of safety. Recommendations were made that the licensee should conduct further in-depth reviews of these issues in order that a final determination of the existing plant's safety margins could be made.

1.2 OBJECTIVE AND SCOPE

The purpose of this report is to document the results of the in-depth evaluations which were conducted. The scope addressed herein relates only to structural elements affected by concrete design code changes, and to any associated load or load combination changes necessary to assess those elements. The load, load combination, and code changes applicable to steel elements were reviewed and analyzed in RG&E's "Structural Reanalysis Program" (reference 3), transmitted to the NRC by letter of April 22, 1983.

In TER C5257-322, the FRC identified 11 concrete code changes as being potentially significant. These code changes occured between ACI 318-63 (reference 4) and either ACI 349-76 (reference 5 - six changes) or ASME B&PV Code, Section III, Division 2, 1980 (reference 6 - five changes). One of these code changes (concerning steel embedments used to transmit loads to concrete) will be addressed in a subsequent RG&E submittal entitled "Evaluation Report for USNRC SEP Topics." It is expected that this report will be transmitted by mid-May. Another of these code changes (concerning in-plane shear in the Containment Shell) was already resolved in the SER transmitting TER C5257-322 to RG&E. The nine remaining code changes are addressed in this report and are listed below:

1. concrete columns with spliced reinforcement

2. brackets and corbels (not on the Containment Shell)

3. elements loaded in shear with no diagonal tension (shear friction)

4. structural walls - primary load carrying (for both a shear wall condition and a punching shear condition)

5. elements subject to temperature variations

6. areas of the Containment Shell subject to peripheral shear

7. areas of the Containment Shell subject to torsion

8. brackets and corbels (on the Containment Shell)

9. areas of the Containment Shell subject to biaxial tension

The impact of the above nine code changes on the following eight Seismic Category I structures was investigated while conducting the evaluation:

1. Containment Shell

2. Containment Interior Structures

3. Auxiliary Building and Spent Fuel Pool

4. Intermediate Building

5. Control Building

6. Diesel Generator Building

7. Cable Tunnel Structure

8. Screen House

Both the extent of application of the nine code changes to Ginna Station and the impact of the code changes on the margins of safety for affected concrete elements are addressed.

2.0 GENERIC LOADS

The following loads are indicated in the TER as potentially applicable to concrete structures and elements in Ginna Station. They are also included in the NRC Standard Review Plan (SRP) Section 3.8.3 and 3.8.4 (reference 7) for Seismic Category I Structures:

D Dead loads or their related internal moments and forces (such as permanent equipment loads).

Eo Loads generated by the operating basis earthquake.

Ess Loads generated by the safe shutdown earthquake.

F Loads resulting from the application of pre-stress.

H Hydrostatic loads under operating conditions.

Ha Hydrostatic loads generated under accident conditions, such as post-accident internal flooding.

L Live loads or their related internal moments and forces (such as movable equipment loads).

Pv Loads resulting from pressure due to normal operating conditions.

Pa Pressure load generated by accident conditions (such as those generated by the postulated pipe break accident).

Ps All pressure loads which are caused by the actuation of safety relief valve discharge including pool swell and subsequent hydrodynamic loads.

Ro Pipe reaction during startup, normal operating, or shutdown conditions, based on the critical transient or steady-state condition.

Ra Pipe reactions under accident conditions (such as those generated by thermal transients associated with an accident).

Rs All pipe reaction loads which are generated by the discharge of safety relief valves.

Ta Thermal loads under accident conditions (such as those generated by a postulated pipe break accident).

To Thermal effects and loads during startup, normal operating, or shutdown conditions, based on the most critical transient or steady-state condition.

Ts All thermal loads which are generated by the discharge of safety relief valves.

W Loads generated by the design wind specified for the plant.

Wt Loads generated by the design tornado specified for the plant. Tornado loads include loads due to tornado wind pressure, tornado-created differential pressure, and tornado-generated missiles.

Yr Equivalent static load on the structure generated by the reaction on the broken pipe during the design accident.

Yj Equivalent static load on the structure generated by the impingement of the fluid jet from the broken pipe during the design basis accident.

Ym Missile impact equivalent static load on the structure generated by or during the design basis accident, such as pipe whipping.

3.0 GENERIC LOAD COMBINATIONS

The TER lists load combinations that apply to most Seismic Catagory I structures at Ginna Station. These load combinations are consistent with the SRP for Seismic Category I Structures and generally comprise all of the possible load combinations to be considered for concrete structures and elements.

The load combinations for all Seismic Category I structures are listed below. For most structures, the load combinations listed are those given in the TER. The load combinations for the Containment Interior Structures are the exceptions, since they were not listed in the TER. The load combinations for the Containment Interior Structures are those listed in ACI 349-80 (reference 8).

Containment Shell:

1. D + L + F + Pv + To + Ro
2. D + L + F + Pv + To + Eo + Ro
3. D + L + F + Pv + To + W + Ro
4. D + 1.3L + F + Pv + To + 1.5Eo + Ro
5. D + 1.3L + F + Pv + To + 1.5W + Ro
6. D + L + F + Pv + To + Ess + Ro
7. D + L + F + Pv + To + Wt + Ro
8. D + L + F + 1.5Pa + Ta + Ra
9. D + L + F + Pa + Ta + 1.25Ra
10. D + L + F + 1.25Pa + Ta + 1.25Eo + Ra
11. D + L + F + 1.25Pa + Ta + 1.25W + Ra
12. D + L + F + Ha + To + Eo + W
13. D + L + F + Pa + Ta + Ess + Ra + Yr + Yj + Ym

Containment Interior Structures:

1. 1.4D + 1.4H + 1.7L + 1.7Ro
2. 1.4D + 1.4H + 1.7L + 1.7Eo + 1.7Ro
3. 1.4D + 1.4H + 1.7L + 1.7W + 1.7Ro
4. D + H + L + To + Ro + Ess
5. D + H + L + To + Ro + Wt
6. D + H + L + Ta + Ra + 1.25Pa
7. D + H +
   L + Ta + Ra + 1.15Pa + 1.0 (Yr + Yj + Ym) + 1.15Eo
8. D + H + L + Ta + Ra + 1.0Pa + 1.0 (Yr + Yj + Ym) + 1.0Ess
9. 1.05D + 1.05H + 1.3L + 1.05To + 1.3Ro
10. 1.05D + 1.05H + 1.3L + 1.3Eo + 1.05To + 1.3Ro
11. 1.05D + 1.05H + 1.3L + 1.3W + 1.05To + 1.3Ro

Note: Underlined loads in combinations 1 and 9 above do not appear in ACI 349-76. Any earth pressure loads are included in live load (L).

All other structures (Auxiliary Building, Control Building, Intermediate Building, Cable Tunnel, Diesel Generator Building, and Screen House):

1. 1.4D + 1.7L
2. 1.4D + 1.7L + 1.9Eo
3. 1.4D + 1.7L + 1.7W
4. .75 (1.4D + 1.7L + 1.7To + 1.7Ro)
5. .75 (1.4D + 1.7L + 1.7To + 1.7Ro + 1.9Eo)
6. .75 (1.4D + 1.7L + 1.7To + 1.7Ro + 1.7W)
7. 1.2D + 1.9Eo
8. 1.2D + 1.7W
9. D + L + To + Ro + Ess
10. D + L + To + Ro + Wt
11. D + L + Ta + 1.5Pa + Ra
12. D + L + Ta + 1.25Pa + Ra + 1.25Eo + Yr + Yj + Ym
13. D + L + Ta + Pa + Ra + Ess + Yr + Yj + Ym

4.0 SPECIFIC LOAD INVESTIGATIONS

Existing records (drawings, calculations, and reports) were reviewed to define loads. Where information was lacking, this approach was supplemented by approximate analyses and engineering judgement. In some cases comparisons were made with other portions of Ginna Station, or with similar designs on other more recent plants. Discussions were held with RG&E and GAI personnel having previous involvement with the plant, and information contained in other SEP Topic reports and GAI reports was utilized. The end result was reasonably representative loads that could be utilized in the code changes assessment.

4.1 APPLICABLE LOADS AND LOAD COMBINATIONS

In the course of this effort, it was found that selected loads from the list contained in Section 2.0 could be generically deleted (for the nine code change items in Section 1.2) from the load combinations for specific buildings listed in Section 3.0. Other loads might also be deleted on a more specific case-by-base basis, but that information was defined during the course of performing the detailed evaluations. The following information indicates which loads were generically deleted from the load combinations for specific buildings, defines the basis and/or source of the deletions, and presents the resulting applicable load combinations.

4.1.1 Containment Interior and Shell

SEP Topic III-5.A addressed the "Effects of Pipe Break on Systems, Structures, and Components Inside Containment". From a review of that topic, there are no significant pipe breaks postulated in the Containment Building which would affect the interior concrete structures. Therefore, pipe break loads Yr, Yj, and Ym were

considered not significant for containment interior structures affected by the concrete code changes. Additionally, Pa and Ta loads were considered insignificant because pressure and temperature differentials would be small, due to no significant pipe breaks, and tend to equalize quickly.

Additional review of each of the code change elements was also conducted for the purpose of defining if the remaining loads, generically applicable to the structure, had any potential impact. As a result of the additional review, loads H, To, W, and Wt were considered not to have any signficant effect on these elements. H loads were not considered because there is no significant hydrostatic head on the containment interior structures. To loads were not considered because they tend to equalize throughout the containment interior, thus resulting in no significant temperature differentials. W and Wt loads were not considered because containment interior concrete is enclosed by the containment shell, which withstands wind and tornado loads. Considering the results of both reviews, the generic load combinations given in Section 3.0 reduce to the following applicable combinations:

Containment Interior Structures:

1. 1.4D + 1.7L + 1.7Ro
2. 1.4D + 1.7L + 1.7Eo + 1.7Ro
3. 1.4D + 1.7L + 1.7Ro
4. D + L + Ro + Ess
5. D + L + Ro
6. D + L + Ra
7. D + L + Ra + 1.15Eo
8. D + L + Ra + Ess

9. 1.05D + 1.3L + 1.3Ro
10. 1.05D + 1.3L + 1.3Eo + 1.3Ro
11. 1.05D + 1.3L + 1.3Ro

For the Containment Shell, Ym was considered not to significantly affect the elements reviewed for concrete code changes, based on a review of the above noted SEP Topic III-5.A, because the postulated major pipe break missile loads are calculated to cause only a small penetration into the shell (considered unlined), and thus does not affect structural integrity. Ha was also considered not to have any significant effect on these same elements, based on a specific element versus load review, because loads imposed by any possible flooding would be minor, particularly with respect to the code change elements. Considering the above, the generic load combinations given in Section 3.0 reduce to the following applicable combinations:

Containment Shell:

1. D + L + F + Pv + To + Ro
2. D + L + F + Pv + To + Eo + Ro
3. D + L + F + Pv + To + W + Ro
4. D + 1.3L + F + Pv + To + 1.5Eo + Ro
5. D + 1.3L + F + Pv + To + 1.5W + Ro
6. D + L + F + Pv + To + Ess + Ro
7. D + L + F + Pv + To + Wt + Ro
8. D + L + F + 1.5Pa + Ta + Ra
9. D + L + F + Pa + Ta + 1.25Ra
10. D + L + F + 1.25Pa + Ta + 1.25Eo + Ra
11. D + L + F + 1.25Pa + Ta + 1.25W + Ra
12. D + L + F + To + Eo + W
13. D + L + F + Pa + Ta + Ess + Ra + Yr + Yj

4.1.2 Auxiliary Building

SEP Topic III-5.B addressed the "Effect of High Energy Pipe Breaks Outside Containment". From a review of that topic, it was determined that there are no significant pipe breaks postulated in the Auxiliary Building, and loads Yr, Yj, Ym, Pa, and Ta are therefore considered not significant. The concrete code change elements were considered not to be significantly impacted by To, due to its small magnitude. Considering the above, the generic load combinations given in Section 3.0 reduce to the following applicable combinations:

1. 1.4D + 1.7L
2. 1.4D + 1.7L + 1.9Eo
3. 1.4D + 1.7L + 1.7W
4. .75 (1.4D + 1.7L + 1.7Ro)
5. .75 (1.4D + 1.7L + 1.7Ro + 1.9Eo)
6. .75 (1.4D + 1.7L + 1.7Ro + 1.7W)
7. 1.2D + 1.9Eo
8. 1.2D + 1.7W
9. D + L + Ro + Ess
10. D + L + Ro + Wt
11. D + L + Ra
12. D + L + Ra + 1.25Eo
13. D + L + Ra + Ess

4.1.3 Auxiliary Building Spent Fuel Pool

As indicated in Section 4.1.2, there are no significant pipe breaks postulated in the Auxiliary Building, and loads Yr, Yj, Ym, Pa and Ta are therefore considered not significant. The concrete code change elements were considered not to be significantly impacted by To, due to its small magnitude, and Ro and Ra, due to the lack of significant piping in the area. Considering the

above, the generic load combinations given in Section 3.0 reduce to the following applicable combinations:

1. 1.4D + 1.7L
2. 1.4D + 1.7L + 1.9Eo
3. 1.4D + 1.7L + 1.7W
4. .75 (1.4D + 1.7L)
5. .75 (1.4D + 1.7L + 1.9Eo)
6. .75 (1.4D + 1.7L + 1.7W)
7. 1.2D + 1.9Eo
8. 1.2D + 1.7W
9. D + L + Ess
10. D + L + Wt
11. D + L
12. D + L + 1.25Eo
13. D + L + Ess

4.1.4 Control Building

The applicable load combinations for the Control Building are the same as those listed in Section 4.1.3 for the Auxiliary Building Spent Fuel Pool, for similar reasons.

4.1.5 Intermediate Building

The consideration of pipe breaks in the Intermediate Building has been addressed in the previously noted SEP Topic III-5.B. As described in that SER, an in-service inspection program has been undertaken to preclude significant pipe breaks. Loads Yr, Yj, Ym, Pa and Ta are considered not significant with respect to the code change elements. Loads associated with To are also considered not significant, based on the small magnitude of To. Considering the above, the generic load combinations given in Section 3.0 reduce to the same applicable combinations as those defined for the Auxiliary Building in Section 4.1.2.

4.1.6 Cable Tunnel

There are no pipes in the Cable Tunnel, and therefore loads Ro, Ra, Yr, Yj, and Ym are considered not applicable. The effects of To were also considered insignificant, because of its small magnitude.

The generic load combinations given in Section 3.0 reduce to the following applicable combinations:

1. 1.4D + 1.7L
2. 1.4D + 1.7L + 1.9Eo
3. 1.4D + 1.7L + 1.7W
4. .75 (1.4D + 1.7L)
5. .75 (1.4D + 1.7L + 1.9Eo)
6. .75 (1.4D + 1.7L + 1.7W)
7. 1.2D + 1.9Eo
8. 1.2D + 1.7W
9. D + L + Ess
10. D + L + Wt
11. D + L + Ta +1.5Pa
12. D + L + Ta + 1.25Pa + 1.25Eo
13. D + L + Ta + Pa + Ess

4.1.7 Diesel Generator Building

From previously noted SEP Topic III-5.B, there are no significant pipe breaks postulated in the Diesel Generator Building. Additionally, since there is no major piping in the building, and thermal loads are insignificant, loads Yr, Yj, Ym, Pa, Ta, Ro, Ra, and To were considered negligible or not applicable. The applicable load combinations for the Diesel Generator Building are the same as those listed in Section 4.1.3 for the Auxiliary Building Spent Fuel Pool.

4.1.8 Screen House

The applicable load combinations for the Screen House Building are the same as those listed in Section 4.1.3 for the Auxiliary Building Spent Fuel Pool, for similar reasons.

4.2 BASES FOR APPLICABLE LOAD MAGNITUDES

The loads contained in the load combinations in Section 4.1 were defined by the methods described in Section 4.0. The following describes the bases used to define load magnitudes, following the categories defined in the TER.

4.2.1 Gravity Loads

Drawings and/or orginal calculations formed the basis for dead (D) and live (L) loads. Concrete and steel weights were considered to be 150 pcf and 490 pcf, respectively. Normal and extreme snow loads were considered to be 40 psf ground snow and 100 psf, respectively.

4.2.2 Pressure Loads

Prestress (F) loads were obtained from the Ginna FSAR (reference 9). Hydrostatic (H) loads were included with live load and were based on original calculations, considering the ground water level to be at Elevation 250'-0". The Ginna FSAR, original calculations, and subsequent studies (SEP Topics III-5.A, III-5.B, VI-2.D, and VI-3) formed the basis for other pressure (Pv, Pa) loads.

4.2.3 Thermal Loads

The Ginna FSAR and subsequent studies (SEP Topics III-5.B, VI-2.D, and VI-3) formed the basis for thermal (To, Ta) loads.

4.2.4 Pipe and Mechanical Loads

The Ginna FSAR, original calcuations, and the results of the Piping Seismic Upgrade Program (described in SEP Topic III-6) formed the basis for Pipe and Mechanical (Ro, Ra) loads.

4.2.5 Environmental Loads

Seismic loads (Eo, Ess) were established using the results of the Reactor Building and Auxiliary Structures Seismic Analysis performed as part of the Ginna Piping Seismic Upgrade Program. Wind (W) and Tornado (Wt) loads were defined from the results of the Structural Reanalysis Program (SEP Topics II-2.A, III-2, III-4.A, and III-7.B), transmitted by letter of April 22, 1983. The tornado wind speed considered was 132 mph.

4.2.6 Impulsive Loads

The Ginna FSAR, original calculations, and subsequent studies (SEP Topics III-5.A and III-5.B) formed the basis for impulsive (Yr, Yj, Ym) loads.

5.0 EVALUATION RESULTS

The following sections present the results of the evaluations of each of the nine concrete code changes noted in Section 1.2. A brief description of the code change is given. The method used to determine the extent of application to Ginna Station is described, as well as the method used to evaluate any findings. The results of any required evaluations are summarized.

5.1 COLUMNS WITH SPICED REINFORCING

ACI 349-76, Section 7.10.3 specifies requirements for columns with spliced reinforcing which did not exist in the ACI 318-63 Code. The ACI 349-76 Code requires that splices in each face of a

column, where the design load stress in the longitudinal bars varies from fy in compression to 1/2 fy in tension, be developed to provide at least twice the calculated tension in that face of the column (splices in combination with unspliced bars can provide this if applicable). This code change requires that a minimum of 1/4 of the yield capacity of the bars in each face of the column be developed by both spliced and unspliced bars in that face of the column.

To assess the impact of this change on Ginna Station, concrete outline drawings, reinforcing fabrication drawings, and available original calculations were reviewed to determine to what extent columns with spliced reinforcing exist. As a result of these reviews, a total of 57 columns with spliced reinforcing was found. They occur in the Auxiliary Building (14), Control Building (1), Diesel Generator Building (6), Intermediate Building (20), and Screen House (16). All of the columns found use lap splices which occur at the bottom of the columns.

To evaluate the columns in the Auxiliary Building, Control Building, Diesel Generator Building, and Intermediate Building, they were divided into groups according to their reinforcing details and size. This grouping resulted in the formation of nine groups of similar columns. The column within each group judged to have the most severe load from the applicable loads and load combinations was chosen for evaluation. Additionally, one column from the Screen House was chosen for evaluation. These columns were evaluated for compliance with ACI 349-76 provisions. The capacity of the spliced reinforcing was calculated in accordance with the code and this capacity was used with the worst case load combination to determine if the code-required factor of safety was met. If the splices did not have the minumum required splice length to fully develop the bar in accordance with ACI 349-76, the splice capacities were reduced by a factor of Lp/Ld (where Lp is the splice length provided and Ld is the ACI 349-76 required splice length).

The results of the above evaluation found all concrete columns evaluated meet and/or exceed the code-required factor of safety.

5.2 BRACKETS AND CORBELS (NOT ON THE CONTAINMENT SHELL)

ACI 318-63 did not have any specific requirements for brackets and corbels. Provisions for these components are included in ACI 349-76, Section 11.13. These provisions apply to brackets and corbels having a shear-span-to-depth ratio of unity or less. The provisions specify minimum and maximum limits for tension and shear reinforcing, limits on shear stresses, and constraints on the member geometry and placement of reinforcing within the member.

Concrete outline drawings and available original calculations were reviewed to determine if brackets and corbels were used at Ginna. A total of twelve corbels was found during these reviews. They occur in the Auxiliary Building (4), Intermediate Building (3), and Containment Interior Structures (5). Seven of these corbels support primary structural elements (e.g., beams, slabs). The remaining five corbels support secondary elements (e.g., a corbel on the Auxiliary Building exterior walls which supports a four inch architectural brick facing) which generally cause no significant load on the corbel.

Corbels having similar geometry and reinforcing details were grouped together, and the corbel from each group judged to have the worst load was evaluated. If this corbel was acceptable, then the others in the group were judged acceptable. The selected corbels were first evaluated for compliance with ACI 349-76 requirements for minimum and maximum reinforcing, geometry constraints, and placement of reinforcing. If all of these requirements were met, the capacity of the corbel was calculated in accordace with ACI 349-76. This capacity was used, along with the load from the worst case load combination, to determine if the

code-required factor of safety was met. If a corbel did not conform to the above requirements, then the shear stresses in the concrete imparted by the loads on the corbel were compared to the code permissible shear stress for unreinforced concrete (even though there actually was some reinforcing in the corbel). If the actual stress was less than that permitted, the corbel was judged acceptable.

The results of the evaluation of the twelve corbels are:

a. Six of the seven corbels supporting primary structural elements meet the code requirements for reinforcing, geometry, and factor of safety. The remaining corbel does not conform to the code requirements for minimum reinforcing, but the stresses in this corbel are small and corbel was judged to have an acceptable margin of safety.

b. The five corbels which support secondary elements do not comply with the code requirements for reinforcing. However, all of these corbels have loads which produce insignificant stressses in the corbels and are therefore judged to have an acceptable margin of safety.

5.3 ELEMENTS LOADED IN SHEAR WITH NO DIAGONAL TENSION (SHEAR FRICTION)

The provisions for shear friction given in ACI 349-76 did not exist in ACI 318-63. These provisions specify reinforcing and stress requirements for situations where it is inappropriate to consider shear as a measure of diagonal tension.

Concrete outline drawings and available original calculations were reviewed to determine if conditions requiring evluation for shear friction exist at Ginna. As a result of this review, a total of 203 shear-friction conditions was found. They occur in the Auxiliary Building (12), Containment Interior Structures (133),

and Screen House (58). These conditions exist for embedded plates supporting steel beams, concrete ledges, removable concrete slabs, beam pockets, and several miscellaneous situations.

To evaluate these conditions found in the Auxiliary Building and Containment Interior Structures, they were divided into a number of groups by similarity, considering their geometry and reinforcing details. This approach resulted in the formation of 15 groups. The condition in each group judged to have the most severe load from the applicable loads and load combinations was evaluated for compliance with the code provisions. Two conditions in the Screen House were also evaluated for compliance with the code provisions.

The controlling conditions were first evaluated by determining their shear friction capacity utilizing only those details strictly conforming to the code. No credit was taken for other reinforcing installed which did not meet ACI 349-76 provisions. This capacity was then compared to the controlling factored load combination to see if the code-required factor of safety was met. If the factor of safety was not satisfied, several alternative evaluation approaches were used to assess safety, and these are described below along with a summary of all results.

The results of the evaluations for this code change indicate the following for the 15 groups in the Auxiliary Building and Containment Interior Structures evaluated:

a. Six groups representing 26 conditions have safety factors that are equal to or greater than the code-required factor of safety, considering only code-satisfying reinforcing.

b. Five groups representing 108 conditions have safety factors that are equal to or greater than the code-required factor of safety, considering code-satisfying reinforcing plus taking

credit for any additional well-anchored reinforcing installed.

c. Two groups representing three conditions have factors of safety that are equal to or greater than the code-required factor of safety for shear stresses in unreinforced concrete. These elements had small loads and the capacities were checked ignoring any reinforcing present in the design.

d. One group representing six conditions (beam pockets for beams supporting the Intermediate Building floor at column line N) have an actual factor of safety less than the code-required factor of safety (considering appropriate load factors), but greater than unity against ultimate failure (with all load factors reduced to 1.0).

e. One group representing two conditions (thrust blocks at the base of each reactor coolant pump) meets the code-required factor of safety assuming an in-situ concrete strength (f'c) of 3300 psi, as opposed to the 28 day strength of 3000 psi. This in-situ strength is judged to be reasonable based upon typical concrete compressive strength increases over long time periods.

The results of the evaluation for this code change in the Screen House show the safety factors are greater than those required by the code considering only code-satisfying reinforcing.

5.4 STRUCTURAL WALLS - PRIMARY LOAD CARRYING

5.4.1 Shear Walls

ACI 349-76, Section 11.15.1 through 11.15.6 specifies requirements for reinforcing and permissible shear stresses for in-plane shear loads on walls. The ACI 318-63 Code had no specific requirements for in-plane shear on shear walls.

Concrete outline drawings and available original calculations were reviewed to determine if shear walls exist at Ginna. All walls which connect a roof or floor to a lower floor were considered to act as shear walls. As a result of the drawing and calculation review, a total of 187 shear walls was identified. They were found in the Auxiliary Building (87), Intermediate Building (1), Control Building (3), Diesel Generator Building (16), Containment Interior Structures (59), and Screen House (21).

To evaluate the shear walls in the Auxiliary Building, Control Building, Intermediate Building, Diesel Generator Building, and Containment Interior Structures, the walls in each building were considered as a separate group. Each group of walls was further broken down by classifying each wall as either an interior or exterior wall. One wall judged to be representative of each classification within the group was then evaluated. If these representative walls were found to be acceptable, then the other walls within their classification were judged acceptable. A wall was evaluated by first determining the controlling load combination for the wall, and then determining the in-plane vertical, in-plane horizontal, and lateral loads on the wall. Using these loads, the walls were evaluated using the code provisions. Vertical and lateral loads on the walls were evaluated in addition to in-plane horizontal loads, because they directly influence the requirements for reinforcing in the walls. The shear walls in the Screen House were qualitatively evaluated by comparison to the Auxiliary Building.

The results of this evaluation are as follows:

a. The shear walls in the Auxiliary Building, Intermediate Building, Control Building, Containment Interior Structures, and Screen House meet the code requirements.

b. The shear walls in the Diesel Generator Building are not adequately reinforced to meet the current code requirements for in-plane loads or flexural bending from lateral loads.

5.4.2 Punching Shear

ACI 349-76, Section 11.15.7 specifies permissible punching shear stresses for walls. ACI 318-63 had no specific provisions for walls for these stresses. Punching loads are caused by relatively concentrated lateral loads on the walls. These loads may be from pipe supports, equipment supports, duct supports, conduit supports or any other component producing a lateral load on a wall.

Concrete outline drawings, available original calculations, and pipe support drawings and load sheets from the Ginna Piping Seismic Upgrade Program were reviewed to determine where punching loads occur and what the magnitude of these loads are. As a result of this review, both pipe and equipment support loads were judged to cause the most severe punching loads.

To evaluate the walls for equipment punching loads, the loads found from the above review were applied to the walls considering the specific details of each design. To evaluate the loads from pipe supports, since there are so many supports, the most severe loads found were applied to the thinnest wall found, conservatively using a six inch square area of application. These loads were used, along with the capacity of the wall calculated in accordance with the ACI 349-76 provisions, to determine if the code-required factor of safety was met.

As a result of the above evaluations, it was found that the walls, in all cases, meet the code-required factor of safety for punching shear.

5.5 ELEMENTS SUBJECT TO TEMPERATURE VARIATIONS

ACI 349-76 Appendix A specifies requirements for consideration of temperature variations in concrete which were not contained in ACI 318-63. These new provisions require that the effects of the gradient temperature distribution and the difference between mean temperature distribution and base temperature during normal operation or accident conditions be considered. The new provisions also require that thermal stresses be evaluated considering the stiffness and rigidity of members and the degree of restraint of the structure.

Concrete outline drawings and pertinent calculations (in buildings where a possible thermal differential condition of any consequence could occur) were reviewed to determine the extent of possible thermal differential conditions in restrained concrete elements.

A total of six possible conditions/elements was found during this review. These conditions occurred in the Containment Interior Structures (5) and in the Cable Tunnel (1). Based on restraint and degree of thermal differential, the Cable Tunnel condition was judged to be the worst case and was therefore evaluated to determine the effect on the factor of safety. The conditions for the Containment Interior Structures are less severe because the temperature differential is less and the temperature would tend to dissipate and equalize.

The evaluation determined the moments in the Cable Tunnel, using the worst loading combination. The actual factor of safety was determined by dividing the theoretical moment capacity of the concrete section by the applied moments due to the loads imposed. This actual factor of safety was then compared to the ACI 349-76 required factor of safety.

The actual factor of safety for the Cable Tunnel was greater than the code-required factor of safety. Because the Cable Tunnel was considered the "worst case" condition for the thermal differential requirement, the remaining five elements were judged to meet the current code requirements of ACI 349-76, Appendix A for thermal loads.

5.6 AREAS OF CONTAINMENT SHELL SUBJECT TO PERIPHERAL SHEAR

Concrete containment design is currently governed by the ASME Boiler and Pressure Vessel Code, Section III, Division 2, 1980. The provisions for peripheral (punching) shear appear in code Section CC - 3421.6. These provisions are similar to the ACI 318-63 Code provisions for slabs and footings, except that the allowable punching shear stress in CC - 3421.6 includes the effect of shell membrane stresses. For membrane tension, the allowable concrete punching shear stress in the ASME Code is less than that allowed by ACI 318-63.

Significant shell punching shear loads can occur at shell penetrations. To evaluate the impact of the code change, all penetrations found from a review of the Containment Shell concrete drawings were documented. As a result of this review, 126 penetrations including two large access openings were identified. Since the punching shear capacity of the shell at penetrations was expected to be closely related to penetration size, the penetrations were grouped by penetration sleeve diameter. The nominal penetration sleeve diameters range from 6" to 54" and the two large access openings are 9'-6" and 14'-0". A total of ten groups of penetrations was defined in this manner.

All penetrations were found to be provided with a circumferential ring arrangement to allow transfer of the punching shear load directly to the concrete. The effect of the peripheral shear code change was evaluated by examining the shell capacity of the

penetrations for current code adequacy. Where simple calculations or judgement showed that a penetration group is clearly adequate, the need for assessment was eliminated. For those groups that were assessed, a "worst case" penetration from each group was chosen and the shell capacity for those penetrations was evaluated. Actual factors of safety were calculated and compared to the factor of safety required by the code. When the shell capacity for the "worst case" penetration in a group was found adequate, the capacity of the other penetrations in the group was judged adequate.

The results of the evaluations are as follows:

a. For penetration groups with 6", 12-1/2", and 14-1/4" diameter sleeves, shell capacity was found adequate by calculations. For these penetrations, the code-specified punching shear capacity of the concrete exceeds the ultimate axial load of the pipe penetration. This axial load is the maximum that the process pipe is capable of developing based on its tensile strength.

b. For penetration groups with 24" and 54" diameter sleeves, the shell capacity was judged to be adequate. No significant punching shear loads were identified, and an evaluation was not considered necessary.

c. At the large access (Equipment and Personnel) openings (one group), significant punching shear loads occur due to containment internal pressure only. Adequacy against punching failure local to the penetration under the Abnormal loading condition (90 psig internal pressure, which is 1.5Pa) was demonstrated by calculations.

d. For the groups with 10" and 24-1/4" diameter sleeves, the shell capacity was shown adequate. The calculated punching

shear loads for the "worst case" penetrations are well below the code-specified punching shear capacity of the concrete. Pipe break loads were used for the evaluation and were obtained by conservatively using a factor of 2.0 times the pipe operating pressure times the pipe area. This method is consistent with current industry practice.

e. For the 29" and 45-1/4" diameter sleeve groups (feedwater and mainsteam penetrations), the shell was found not to meet the current code-required factor of safety when using pipe rupture loads from the original plant design calculations. However, the actual factor of safety is greater than 1.0, thereby providing a margin of safety against ultimate failure.

5.7 AREAS OF CONTAINMENT SHELL SUBJECT TO TORSION

Concrete containment design is currently governed by the ASME Boiler and Pressure Vessel Code, Section III, Division 2, 1980. Section CC-3421.7 of the code contains provisions for the allowable torsional shear stress in the concrete. Such provisions were not contained in the ACI 318-63 Code. The present allowable torsional shear stress includes the effects of the membrane stresses in the containment shell, and is based on a criteria that limits the principle membrane tension stress in the concrete.

Only two types of penetrations, the main steam and feedwater, are provided with torsion resisting elements which rely upon the concrete capacity. In both cases, redundant elements are provided. The penetration sleeves have lugs welded to them, which could resist torsional loads and impart torsional shear stresses to the concrete. However, the final design noted in the original calculations shows that the tie rods incorporated into the penetration details were adequately designed to resist torsion. These tie rods do not rely upon the torsional shear capacity of

the concrete, and, therefore, a torsional shear stress check was not required.

5.8 BRACKETS AND CORBELS (ON THE CONTAINMENT SHELL)

The ACI 318-63 Code did not specify requirements for brackets and corbels. Provisions for these components are included in the ASME Boiler and Pressure Vessel Code, Section III, Division 2, Section CC-3421.8. These provisions apply to brackets and corbels having a shear-span-to-depth ratio of unity or less. The provisions specify minimum and maximum limits for tension and shear reinforcing, limits on shear stresses, and constraints on the member geometry and placement of reinforcing within the member.

Concrete outline drawings and original calculations for the Containment Shell were reviewed to determine if brackets and corbels were used in its design. As a result of the review, no brackets or corbels were found on the Containment Shell. Therefore, no further evaluation was required.

5.9 AREAS OF CONTAINMENT SHELL SUBJECT TO BIAXIAL TENSION

Increased tensile development lengths are required for reinforcing steel bars terminated in biaxial tensile areas of reinforced concrete containment structures in accordance with Section CC-3532.1.2 of the ASME Boiler and Pressure Vessel Code, Section III, Division 2, 1980. For biaxial tension loading, bar development lengths, including both straight embedment lengths and equivalent straight length for standard hooks, are required to be increased by 25% over the standard development lengths required for uniaxial loading. Nominal temperature reinforcement is excluded from these special provisions. ACI 318-63 had no requirements related to this increase in development length.

Containment Shell concrete outline drawings were examined to identify the areas where the main reinforcing bars are terminated with either straight development lengths or standard hooks. Special attention was paid to such areas as penetrations, where bars are likely to be terminated. The drawing review revealed nine areas where the main reinforcing bars in the wall and dome are terminated. These cases involve vertical reinforcement in the wall and meridional bars in the dome above the ring girder. Main horizontal wall bars were found to be terminated using positive mechanical anchorage devices (such as Cadwelds and structural steel shapes) that are capable of transferring forces to other reinforcement. Typically, main horizontal and vertical bars terminated at penetrations are anchored using these positive mechanical anchorages. However, the drawing review revealed seven additional areas where supplementary bars are terminated at penetrations.

Thirteen of the 16 areas were evaluated individually by first determining the location of the critical section to be evaluated and then comparing the tensile development lengths required for the controlling load combination to he development lengths provided. The remaining three areas are similar to three of the areas evaluated, and individual evaluation was not considered warranted.

In all of the 13 areas evaluated, the provided tensile development lengths exceeded ASME Code requirements. In several of the areas investigated, bars were actually terminated outside of the biaxial tensile stress area (i.e., in compressive areas which are excluded from these special requirements). As a result of this evaluation, it is concluded that the code change did not reduce the Containment Shell margin of safety.

6.0 CONCLUSIONS

As a result of the evaluations described in Sections 5.1 through 5.9 for all structures except the Screen House, the following conclusions can be made regarding the effect of the concrete code changes on the margins of safety.

Elements or conditions affected by the following code change items meet or exceed the current code-required factors of safety for the worst cases evaluated and, therefore, for all concrete elements found that are in the groups represented by the worst cases: concrete columns with spliced reinforcement, brackets and corbels (not on the Containment Shell), structural walls-primary load carrying (punching shear condition), elements subject to temperature variations, and areas of the Containment Shell subject to biaxial tension.

For elements loaded in shear with no diagonal tension (shear-friction), all groups except one meet or exceed the code-required factor of safety. The one group (which represents six elements) which does not meet the code-required factor of safety still has a factor of safety greater than 1.0, which precludes overstress and provides some margin of safety against failure.

For areas of the Containment Shell subject to peripheral shear, all groups except the main steam and feedwater pipe penetration areas meet or exceed the code-required factor of safety. For the main steam and feedwater penetration areas, the factor of safety is less than that required by the code but is still greater than 1.0, which precludes overstress and provides some margin of safety against failure.

For areas of the Containment Shell subject to torsion, it was found that no torsional shear stresses are transmitted to the concrete of the shell from penetrations and, therefore, the factor of safety is not affected.

For brackets and corbels in the Containment Shell, it was found that none exist and, therefore, this code change is not applicable.

For structural walls-primary load carrying (shear wall condition), all sampled representative walls from groups except one representing the Diesel Generator Building meet or exceed the code-required factor of safety. For shear walls in the Diesel Generator Building, current code criteria are not met, because of the new code provisions for in-plane shear.

The only code changes which affect concrete elements found in the Screen House are those which address columns with spliced reinforcing, shear walls, and shear friction. A sample of those elements found to be affected was evaluated for compliance with the code considering the load combination judged to be the most severe. All elements evaluated were found to satisfy the code-required factor of safety.

REFERENCES

1. Franklin Research Center, Technical Evaluation Report - "Design Codes, Design Criteria and Loading Combinations," TER-C5257-322, December 23, 1982.

2. Letter and Attachment from D. Crutchfield, NRC, to J. Maier, RG&E, dated April 21, 1982 - "Design Codes, Design Criteria, and Load Combinations."

3. RG&E Report "Structural Reanalysis Program," transmitted to the NRC by letter of April 22,1983.

4. American Concrete Institute (ACI) - "Building Code Requirements for Reinforced Concrete," ACI 318-63.

5. American Concrete Institute (ACI) - "Code Requirements for Nuclear Safety Related Structures," ACI 349-76.

6. American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, Section III, Division 2, 1980.

7. USNRC Standard Review Plan, Section 3.8.3, "Concrete and Steel Internal Structures of Steel or Concrete Containments," Revision 1, July 1981 and Section 3.8.4, "Other Seismic Category I Structures," Revision 1, July 1981.

8. American Concrete Institute (ACI), "Code Requirements for Nuclear Safety Related Structures," ACI 349-80.

9. Rochester Gas & Electric Corporation, Robert Emmett Ginna Nuclear Power Plant Unit No. 1, Final Facility Description and Safety Analysis Report.