VIRGINIA ELECTRIC AND POWER COMPANY

RICHMOND, VIRGINIA 23261

September 29, 1989

United States Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Serial No. 89-589
NO/JDH:jmj
Docket Nos. 50-338
50-339
License Nos. NPF-4
NPF-7

Gentlemen:

VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION UNITS 1 AND 2
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

On March 10, 1988, Virginia Electric and Power Company submitted a Technical Specification change to revise the allowable differential settlement between the Service Building and the Unit 2 Main Steam Valve House. On August 3, 1989, an NRC letter requested additional information associated with that submittal.

As you know, Virginia Electric and Power Compa. , has been reassessing the entire Settlement Monitoring Program for North Anna Power Station. A thorough examination of existing data by our Engineering organization has resulted in a technical report which details their findings. Using this report as a basis, we plan to submit a Technical Specification change which broadly addresses the entire differential settlement issue and would result in a significant change in the scope of the current specification.

In your August 3, 1989 letter, you indicated that the response to your request for additional information need not be supplied until the broad-scope Technical Specification change request was submitted. However, the specific change proposed in our March 10, 1988 request will be a part of the broader-scope submittal as well. Therefore, we are providing a response (Attachment 1) to your questions at this time and request that you continue your technical review of the change. We believe that by providing the additional information and resolving your current concerns, the effort needed to review our subsequent submittal will be minimized.

If you have any questions or require additional information, please contact us immediately.

Very truly yours,

W L Stewart

W. L. Stewart
Senior Vice President - Power

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Mr. J. L. Caldwell
NRC Senior Resident Inspector
North Anna Power Station

Attachment 1

Response to Additional Questions

NRC Letter Dated August 3, 1989

Question 1. The results indicate that the relative displacement of the encased pipes is much larger than that of the open pipes (Reference 1, page 48B, nodes 5C, 25C and 40C) although the rigidity of the encased pipes is much greater than that of the open pipes. This appears inconsistent and should be explained. It is recognized that the elastic spring assumed for the soil will also control the displacement values.

Answer 1. The encased portion of the pipe is located towards the Service Building end, where most of the settlement occurs. The piping model was analyzed with an imposed displacement at the Service Building end. Therefore, it is clear that the displacements in the encased portion of the pipe are larger for maintaining continuity. The unencased portion of the pipe is a short portion and is away from the encased end where the displacement is applied. The displacement profile appears to be inconsistent, but truly is not. Stiffer soil springs were used in the encased portion of the pipe than the soil spring used in the non-encased portion. A coefficient of vertical subgrade reaction of 300 tons/cu. ft. was used for the encased portion which is on stiff structural fill and a coefficient of vertical subgrade reaction of 100 tons/cu. ft. was used in the non-encased portion which is resting on backfill following the modification. It is recognized that the elastic soil spring assumed for the soil also controls the displacement profile to some extent. However, for this case, the larger displacement at the stiffer end, which is supported by stiffer soil springs, is due to the applied displacement at that end alone. The use of the soil spring, in this case, does not contribute to the apparent inconsistency.

Question 2. Please provide the following information:

(a) The basis for the subgrade coefficient and the anchor stiffness values assumed in the analysis.

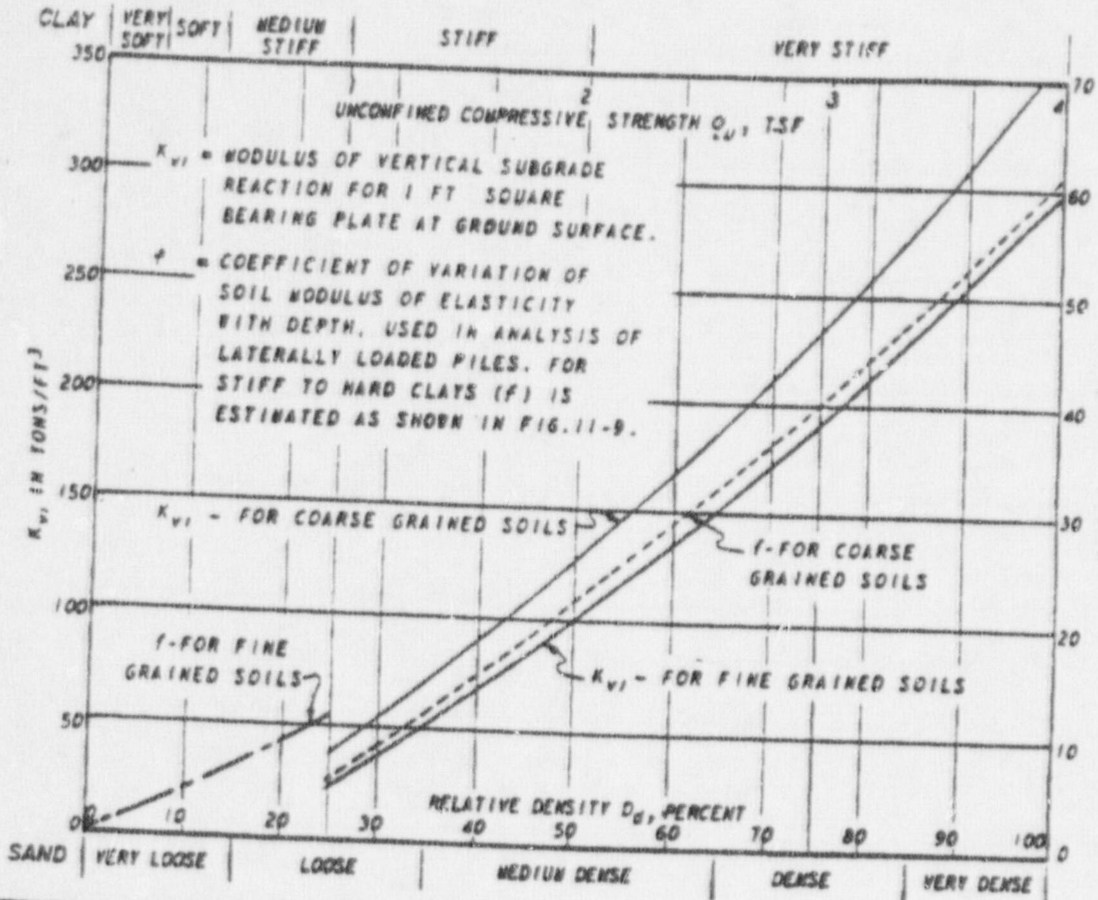
(b) A layout drawing of the pipe line including the attachments at anchor points.

Answer 2. (a) The subgrade coefficient used in the analysis is taken from NAVFAC DM-7, "Soil Mechanics, Foundations and Earth Structures" March 1971, Figure 11-8 (copy attached). For structural fill which was placed under the concrete-encasement, a value of 300 tons per cubic feet was used in the analysis. This value corresponds to dense to very dense coarse grained soils. For the fill adjoining the unencased pipe, which was deliberately placed in a loose condition, a value of 100 tons per cubic feet was used. This value corresponds to nearly mid-range of medium dense coarse grained soils. Thus the values of subgrade coefficients used in the analysis represent upper bound estimates to yield higher stress in the pipe than is likely to exist.

The anchor stiffnesses used in the analysis are documented in Stone and Webster Engineering Corporation calculation 14938.01-S-16, "Determination of Stiffness of Service Water Pipe Encasement for 24" Diameter Lines at MSVH-SB." The translational and rotational stiffnesses provided by the concrete encasement is developed by using beam on elastic foundation analogue. The elastic foundation for the pipe is the concrete encasement for which the subgrade modulus is developed using Vesic's methodology (Reference: "Bending of Beams Resting on Isotropic Elastic Solid," Alexander Vesic, Journal of the Engineering Mechanics Division, Proceedings of the American Society of Civil Engineering, April 1961, Volume 87, No. EM2"). The values of translational and rotational anchor stiffness used in the pipe stress analysis are more than the stiffnesses calculated at the anchors. Thus the anchor stiffnesses used in the analysis provide conservative estimates of stress in the pipe.

(b) Copies of Figures 3.8-76, 3.8-79 and 3.8-80 from the North Anna Updated Final Safety Analysis Report showing the piping layout and anchorage are attached. Additional details are also provided in the attached Figure 7 titled "Foundation Conditions Along Column Line '14' - Main Steam Valve House and Service Building North Anna Power Station Units 1 and 2."

NAVFAC DM-7



DEFINITIONS

δ_v = FOOTING SETTLEMENT
q = FOOTING UNIT LOAD IN tsf
B = FOOTING WIDTH
L = FOOTING LENGTH
D = DEPTH OF FOOTING BELOW GROUND SURFACE
E_s = MODULUS OF ELASTICITY OF SOIL
C_s = SHAPE COEFFICIENT OF LOADED AREA

FOR COARSE GRAINED SOILS AND VERY SOFT TO MEDIUM STIFF FINE GRAINED SOILS, E_s IS ASSUMED TO INCREASE LINEARLY WITH DEPTH ($E_s = fZ$)

FOR STIFF TO HARD CLAYS E_s IS ASSUMED TO BE CONSTANT WITH DEPTH.

COARSE GRAIN SOILS

(MODULUS OF ELASTICITY INCREASING LINEARLY WITH DEPTH)

SHALLOW FOOTINGS $D \leq B$

FOR $B \leq 20$FT:

$$\delta_v = \frac{4qB^2}{K_{v1}(B+1)^2}$$

FOR $B \geq 40$FT:

$$\delta_v = \frac{2qB^2}{K_{v1}(B+1)^2}$$

INTERPOLATE FOR INTERMEDIATE VALUES OF B

DEEP FOUNDATION $D \geq 5B$

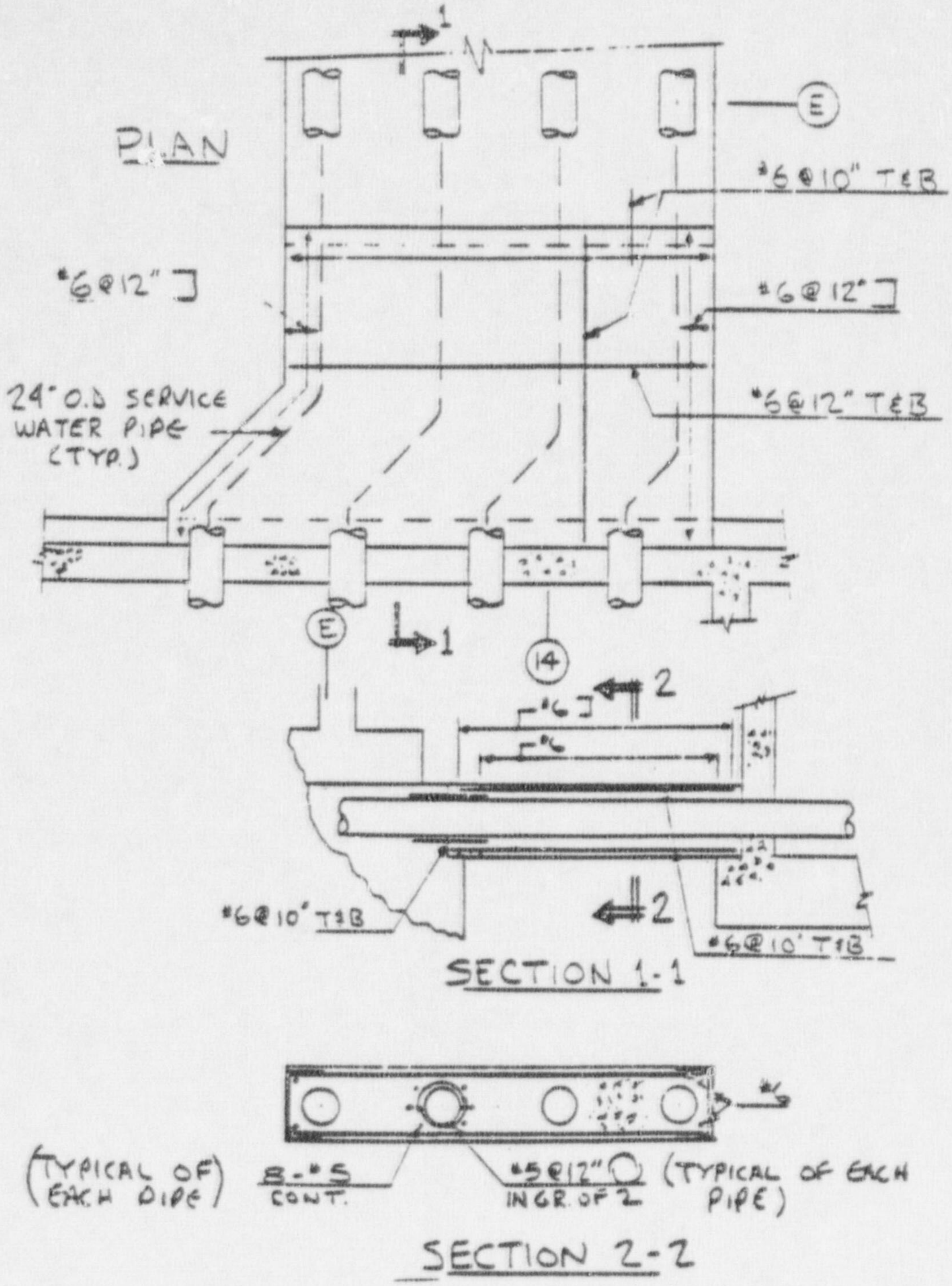
FOR $B \leq 20$FT:

$$\delta_v = \frac{2qB^2}{K_{v1}(B+1)^2}$$

NOTES: 1. NONPLASTIC SILT IS ANALYZED AS COARSE GRAINED SOIL WITH MODULUS OF ELASTICITY INCREASING LINEARLY WITH DEPTH.

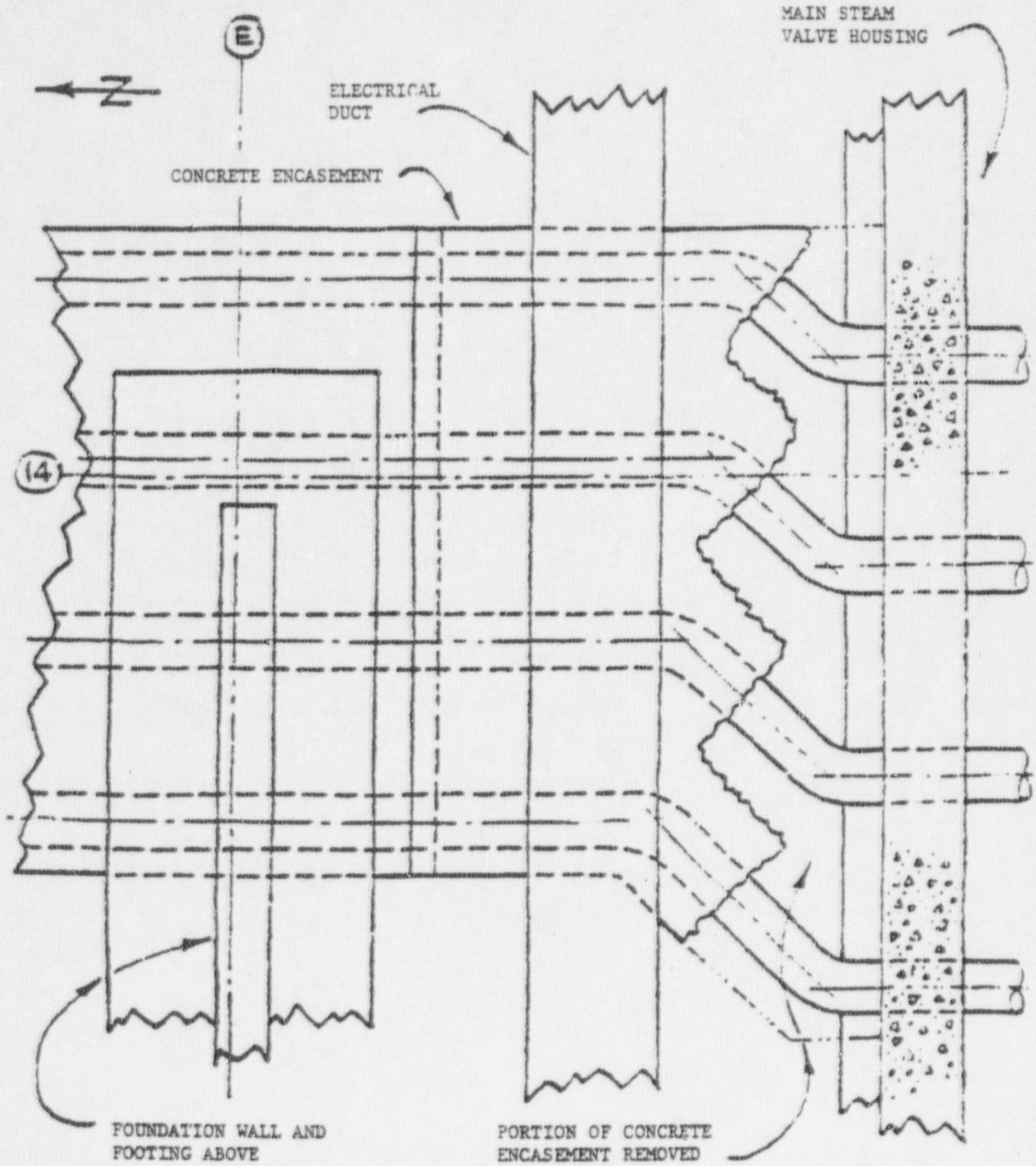
2. VALUES OF K_{v1} SHOWN FOR COARSE GRAINED SOILS APPLY TO DRY OR MOIST MATERIAL WITH THE GROUND WATER LEVEL AT A DEPTH OF AT LEAST 1.5B BELOW BASE OF FOOTING. IF GROUND WATER IS AT BASE OF FOOTING, USE $K_{v1}/2$ IN COMPUTING SETTLEMENT.

FIGURE 11-8
Immediate Settlement of Isolated Footings on Coarse Grained Soils

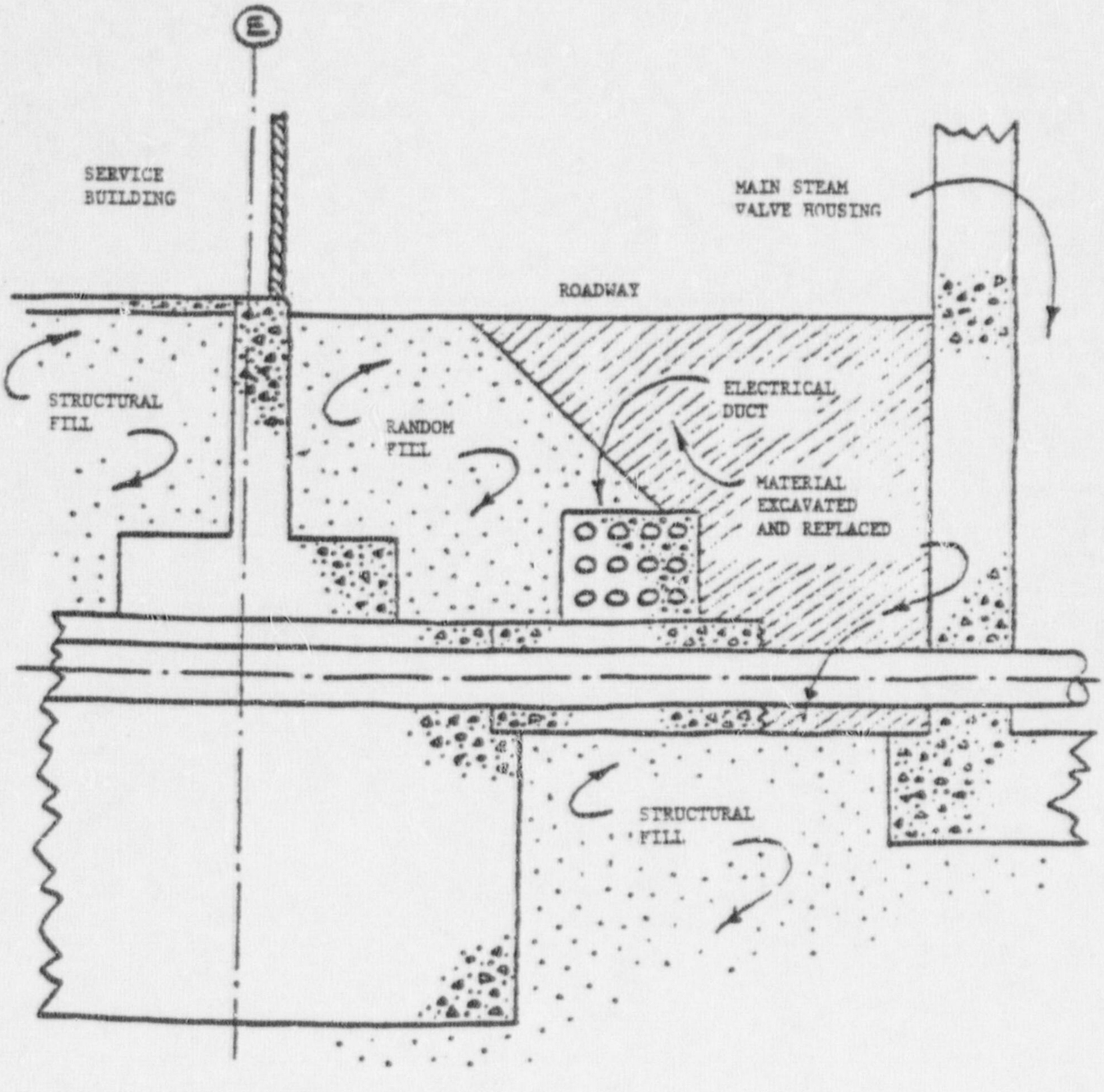


NOTE: THIS FIGURE SHOWS THE ORIGINAL ARRANGEMENT. THE EXTENT OF THE REMOVED CONCRETE ENCASEMENT AND REINFORCING STEEL IS SHOWN ON FIGURE 3.8-79.

SERVICE WATER PIPING BEFORE MODIFICATION



PLAN OF REPAIR OF SERVICE WATER LINES



NOTE: BACKFILL BENEATH AND 2 FT ABOVE EACH PIPE LIGHTLY COMPACTED, WHILE MATERIAL BETWEEN AND TO EACH SIDE OF PIPES HEAVILY COMPACTED.

SECTION THROUGH REPAIR OF SERVICE WATER LINES

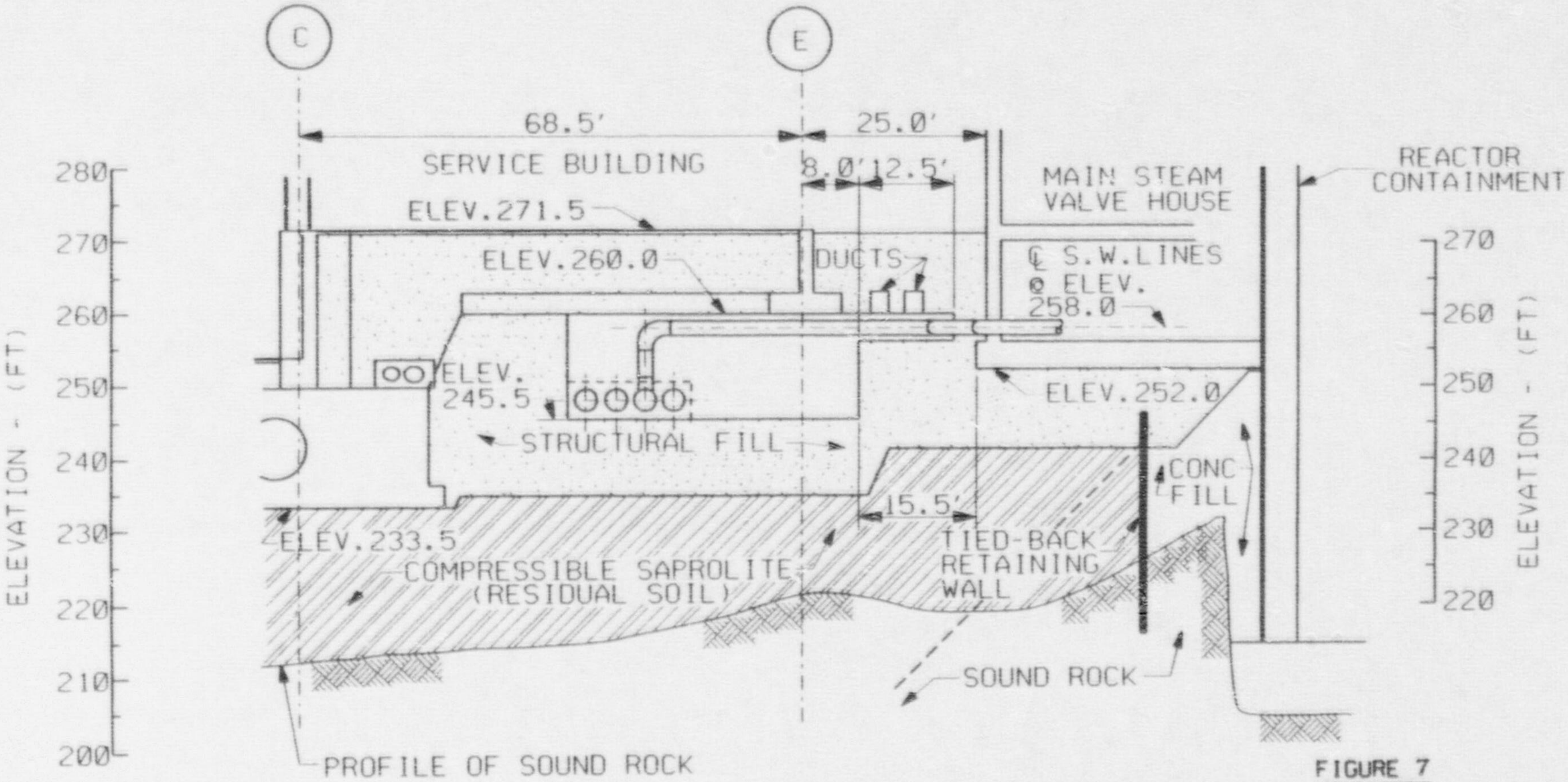


FIGURE 7

FOUNDATION CONDITIONS ALONG COLUMN LINE '14' - MAIN STEAM VALVE HOUSE AND SERVICE BUILDING

NORTH ANNA POWER STATION

UNITS 1 AND 2

SCALE: NOT TO SCALE

Question 3. Please justify the use of the formula for a rectangular cross section in computing the soil stiffness value for the open pipe.

Answer 3. The use of the formula for a beam with a rectangular cross-section on elastic foundation provides a reasonable estimate of subgrade modulus when used for this application. The loose backfill placed under the pipe is in contact with the pipe along its circumference and is laterally confined by the more densely compacted fill placed between the pipes. This more densely compacted material ensures that contact between the pipe and loose backfill is not disrupted as the pipe deflects. Consequently, the use of the projected areas of the pipe to estimate the subgrade modulus is reasonable.

Question 4. Since it is difficult to accurately estimate the analysis parameters (e.g. soil spring constant, spacing of springs, anchor stiffness), the effect of variation of the parameters should be investigated considering bounding values.

Answer 4. Conservative estimates of soil spring stiffness, the spacing of springs, and anchor stiffness were used in the analysis to determine stress in the pipe. However, to evaluate the effect of variation of the parameters on the level of stress in the pipe, a parametric study was undertaken. The results of this study demonstrate that there is no significant sensitivity of critical pipe stress levels to a reasonable bounding increase or decrease in these parameters.

Soil Spring Stiffness: The soil spring stiffnesses were varied by a 20 percent increase and a 20 percent decrease from the values used in the analysis of record. The results indicate that the change in critical stress levels is less than ±4.5 percent when compared to the original analysis.

Spacing of Springs: The node point spacing was carefully selected such that the continuum could be closely represented by a number of discrete members and also the continuous soil supports could be represented by a discrete number of soil springs without significantly affecting the structural behavior. The analytical method applicable to beams on elastic foundation was used as a basis for selecting node spacing. The node point spacings used in the analysis are significantly less than that which is theoretically required to produce a reasonable result. Therefore, the stress generated in the pipe is not sensitive to node point spacings closer than those used in the analysis. In order to assess that effect, the spacings of the springs were further reduced to 2.5 feet or less. The results indicate that the change in critical stress levels is less than 0.6 percent when compared to the original analysis.

Anchor stiffness: The anchor stiffnesses used in the analysis are higher than those calculated for the anchors to get an upper bound estimate of pipe stress. However, to study the effect of variation of anchor stiffness on the pipe stress, the translational anchor stiffness at the Service Building wall and at the Main Steam Valve House wall was increased by factors of 2 and 10 times over the values used in the original analysis. The stiffness was then decreased by factors of 2 and 10 times. The results indicate that the change in critical stress levels is less than ±1 percent.

Question 5. Reference 2 mentions a stress value of 44,176 psi corresponding to a settlement of 0.047 ft. This stress value apparently does not correspond to that computed in Reference 1. This apparent inconsistency may be addressed in the "1981 Report" which is not available at NRC. Please provide this report and explain the inconsistency.

Answer 5. Vepco letter Serial Number 87-746 dated March 10, 1988 mentioned the highest stress value of 44,176 psi in the pipe. This stress value is a conservative number based on the Stone and Webster Engineering Corporation calculation #12050-NP(B)-094-X9, Revision 1, supplied to the Commission. Pages 43 through 45 of the calculation provide results of stress analysis for 3/8" (.03') differential settlement after July 1977. Page 39 of the calculation shows a residual stress of 29,504 psi at reference node point 5B prior to modification of the pipe (prior to 7/77). The results of the analysis is prorated 1.5 times for 9/16" (.047') differential settlement after July 1977 and gives a stress value of 44,176 psi as shown below:

For reference node point 5B, pipe stress due to differential settlement of 9/16" is 29504 + 9781 X 1.5 = 44,176 psi. A more detailed evaluation later showed a stress of 40,046 at the same reference point as shown in page 48D of the calculation. To be consistent with the methodology used in the original evaluation, the conservative magnitude of 44,176 psi was reported in the letter Serial Number 87-746 dated March 10, 1988.

Question 6. Since a small amount of settlement (e.g., on the order of ½ inch) produces a stress value comparable to the allowable limit, the true relative displacements and the resulting strains should be more carefully monitored rather than depending on the survey results of the buildings. For this small value, the actual relative displacements between two ends of the pipe line may be significantly different than from what are being predicted by survey results. It is recognized that some consideration to alternate monitoring methods has been discussed in Reference 3. However, it is suggested that the feasibility of monitoring by direct measurement (e.g. strain gauges, etc.) be further explored. (Note that the survey results indicate a higher settlement at point 114 than that at point 117).

Answer 6. As discussed previously in our letter Serial Number 89-175 dated March 23, 1989 the use of strain gauges to accurately measure the strain in the Service Water Lines (SWL) between the Service Building and the Unit 2 Main Steam Valve House (MSVH) is not considered feasible.

The predicted location of the highest pipe stress due to the limiting settlement value is within the portion of pipe encased in concrete and therefore, application of strain gauges in the vicinity of that location would not be possible.

The nominal stress caused by the limiting settlement on the non-encased sections of the pipe is extremely small. The only significant stress in the non-encased sections is predicted at elbow locations with the use of a stress intensification factor of 4.27. Stress intensification factors are used as multipliers on the nominal stress to arrive at an intensified stress. Stress intensification factors are derived from fatigue tests of components. A measurement using a strain gauge cannot accurately provide intensified stress. Moreover, any measurement performed on the non-encased portions has to be used in analysis to predict strains on the critical encased sections for the purpose of verification. Therefore, the application of strain gauges in the non-encased portions will not provide any reliable independent verifications of strain in the encased portion of the pipe.

The installation of strain gauges can only measure the increase in strain from the time the gauges are installed. The incremental differential settlements over a period of time, currently being determined by the survey, is so small that the increased strains due to the increased differential settlement may not be measurable. At any time, the measured strain from the strain gauges installation will reflect the combined effects of pressure, deadweight, thermal expansion, surcharge, and other operational loadings. It would not be possible to separate out the strain due to different loadings and assign any meaningful value to the strain increment due to differential settlement alone.

In addition, there is always the physical limitation of installing strain gauges 13 feet under ground in adverse environmental conditions and securing them properly to get readings with sensitivity comparable to laboratory conditions.

The settlement monitoring points presently located on the E-line of the Service Building (points 114, 115, 116, and 117) are actually on an interior floor slab slightly north of E-line at elevation 271.5. This slab is structurally independent of the Service Building and is supported by compacted backfill.

It is proposed to relocate point 117 to the exterior E-line wall of the Service Building. The continuous E-line wall footing bears directly on the SWL concrete encasement at Column E-14 (location of point 117). The differential settlement between the Service Building (point 117) and the Unit 2 Main Steam Valve House (point 113) will be measured by direct reading from a single survey instrument set-up. This procedure will minimize random error associated with a level loop involving several set-ups and will result in data accuracy consistent with the ability to accurately read the survey rod (±0.003 feet). Because the wall foundation bears directly on the SWL encasement, the differential settlement recorded between the relocated point 117 and point 113 will reliably reflect the true movement of the SWL.

Additional details for settlement monitoring of points 117 and 113, as well as points 114 and 116, will be provided in a Technical Report that will accompany the Technical Specifications Change Request that addresses the entire Settlement Monitoring Program (Technical Specification 3/4.7.12).

Question 7. It is not clear whether VEPCO is requesting removal of the settlement monitoring requirements in the Technical Specifications for both the old and the new (replacement) pipes or for only the old pipes that have been removed (Reference 2, Attachment 2, first page, Discussion Section). This should be clearly stated.

Answer 7. The intent of the discussion section in the first page of the Attachment 2 of VEPCO letter Serial Number 87-746 dated March 10, 1988 was to request the deletion from the Technical Specification of the settlement monitoring requirements for those pipes which were taken out of service during Service Water improvement project in 1987. It is not intended to remove from monitoring the new settlement monitoring points which were added to the Technical Specification in March 27, 1987 for the newly installed pipes. The marked-up pages of Table 3.7-5 included with our letter Serial Number 87-746 dated March 10, 1988 reflect those changes.

In order to clarify the discussion section of the first page of the Attachment 2 of our letter Serial Number 87-746 dated March 10, 1988, the discussion section should read as:

"The proposed changes to Technical Specification Section 3.7.12, Table 3.7. 5 delete the settlement monitoring requirements for the Service Water lines which were removed from service during the Service Water Reservoir Improvement Project in 1987".