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To,
Col. C. M. Unnithan
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Subject: Responses on the report by Bureau Veritas (dated April 2021) – Chander Kunj Apartments, Silver Sand Island, Vytilla, Kochi

Dear Col. Unnithan,

I have reviewed the first BV Report (dated December 2020) and highlighted the drawbacks. It seems that BV has taken it seriously and performed some additional tests and incorporated the findings in the Report 2 (dated April 2021). However, Report 2 still lacks (1) the presentation of data on the tests conducted on basement and stilt floors and (2) tests on intermediate floors of the buildings. Table 1 provides my responses/suggestions against some of the key inferences in the BV Report 2. The inferences provided clearly indicate that the root causes of corrosion could be either admixed chlorides and/or carbonation. It is recommended to conduct additional chloride and carbonation tests on every other intermediate floors and provide a revised report with the data and tests from intermediate floors as well. These tests can be done on core samples (50 mm dia. x 25 mm depth) collected from within the cover concrete region – hence, no structural issue. These tests can be done and a revised report can be submitted within a period of one month. Additional chloride/carbonation data and results will help optimize the repair strategy to achieve durable repair with minimal cost implications.

Also, the repair strategy suggested in Report 2 is not sufficient to provide a repair-free life of another 20+ years. Experience says that such repair strategies would lead to *halo effect* and *residual chloride effect* (as mentioned in my journal paper; already shared with you). To provide a durable repair, an electrochemical repair strategy (say, cathodic protection) seems essential in the case of this building contaminated with chlorides; and probably carbonation too. Also, life cycle cost of such electrochemical repair strategies will be much less than the repair strategies suggested in BV Report 2. Serious review is required on the repair strategies.

Table 1: Specific comments on the key inferences in BV Report (dated April 2021)

#	Inferences copied from BV Report 2	My response
1.	From the results of Non-destructive ultrasonic pulse velocity & rebound hammer tests, it inferred that the quality of concrete in the tested RC members in Towers B and C are **Doubtful to good concrete**, and the RC members in Tower A were found to be **Good concrete**	Integrity of concrete is "doubtful to good". Indicates there is no significant honeycombing or voids in the concrete. It is reasonable to assume that the integrity of concrete in the upper floors of Towers B and C can also be in "doubtful to good" category.
2.	From the results of Rebound Hammer test, it is inferred that the quality /surface hardness of tested RC Slab of identified floors of Tower A, B and C is found to be **satisfactory**.	The calculated strength values range from about 24 to 30 N/mm^2 and are categorized as '*satisfactory*'. This inference needs to be justified. ***R2a****: Include a comparative table with information on the design grade of the concrete and the calculated compressive strength obtained using the rebound hammer test. Provide this table and justify the inference on why this is satisfactory.*
3.	From the results of the Half-Cell Potential Measurement Test, it is inferred that the probability of corrosion falls in the category of "**Moderate to Advance**" stage of corrosion in the tested RC members of identified floors of Towers B & C	The report uses the term "identified floors". However, I could not find the Floor Numbers corresponding to the tests. Please respond with the page numbers where this information is given in Report 2. If not given, then provide this. Also, page 22 refers to Table 3 and 3A for half-cell potential (HCP) readings. However, I could not find any table in this 32-page BV Report 2. The BV Report 2 seems not reviewed adequately. Without providing the data on floor numbers and HCP data, I cannot judge if this inference is reasonable. ***R3a:*** *Provide the table with half-cell potential data.*
4.	From the results of carbonation test, it is inferred that the carbonation front **has reached up to reinforcement level** from the surface in most of the tested RC members of identified floors of Tower B & C. **"…considering the age of the concrete,** the depth of carbonation in the affected members is more than expected…"	Need more data to make a judgment on the inference provided in the Report 2. ***R4a:*** *Provide information on the time lapse between fracturing of concrete and the phenolphthalein tests?* ***R4b****: Provide the carbonation depth data from each point tested and photos of the phenolphthalein tests already conducted.* ***R4c***: *Core a concrete sample (50 mm dia. x 25 mm depth) from each floor and perform carbonation tests. Provide carbonation depth data and photos of phenolphthalein tests.*

5.	From the results of chloride content test, it is inferred that the level of chloride content in all the tested samples of RC members of identified floors of Tower B & C are beyond the permissible limit of 0.6 kg/m^3	The results shown in Section C.4 (Page 23) of the B V report do not provide information on the floor level and whether the samples are collected from interior or exterior members. This information is necessary to decide whether to have a generalized repair strategy or a customized repair strategy for various types of structural elements in each floor. ***R5a*: *Provide a table with chloride test data from each sample. Also, mention which standard chloride test procedure has been adopted?*** ***R5b*: *Provide the chloride concentration of the water in the surrounding river.***
6.	**Less cover provided for RC members.** The cover concrete specified as per sketch ST-WD-REB.117C-018 are as follows: Column – 35 mm, Beam – 30 mm Slab – 30 mm	The results from the cover depth measurements are not mentioned anywhere in the new report. Inference is not reasonable ***R6a*: *Provide a table with data on specified cover depth and measured cover depth.***

I had given similar suggestions in my previous review of BV Report 1. However, BV Report 2 did not address all the comments adequately. Please ensure that the next report from BV provides the data requested in R2a, R3a, R4a, R4b, R4c, R5a, R5b, and R6a and addresses the comments adequately. Without adequate response to these, I cannot provide additional judgments and provide a customized repair strategy.

I am available to provide any guidance to BV for the additional testing and developing cost-effective and durable repair strategy, if needed. Please feel free to contact me if you have any queries or need clarifications.

Regards

Radhakrishna G Pillai