L3063-GEO: Sustainable Urban Transport Investment Program
ENGINEERING, PROCUREMENT, CONSTRUCTION MANAGEMENT
AND SUPERVISION OF THE MODERNIZATION OF TBILISI-RUSTAVI
SECTION (SECTION 2) OF THE TBILISI-RED BRIDGE (AZERBAIJANI BORDER) ROAD

UPDATED IEE FOR SECTION 2

v. III Annex 10

Investigation of Structural Integrity of, and Impact of Vibration and Noise on Buildings at a Segment of Tbilisi-Rustavi Road Project (Section 2, km 5,2-6,9)

FINAL CONSOLIDATED PROJECT COMPLETION REPORT AND RECOMMENDATIONS

(Prepared by: N.E.P. Nord Est Progetti S.r.**l.** Società di ingegneria (Italy))

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Nord Est Progetti S.r.l.
Società di ingegneria

From : *Dott. Ing. Enrico Musacchio*

Team Leader, Project: Investigation of Structural Integrity of, and Impact of Vibration and Noise on Buildings at a Segment of Tbilisi-Rustavi Road Project (Section 2, km 5,2-6,9)

To: Municipal Development Fund

Cleared by: Mr. Michele Massaccesi (Individual Consultant/Supervisor of Works)

CC: ADB Resident Mission in Georgia

FINAL CONSOLIDATED PROJECT COMPLETION REPORT AND RECOMMENDATIONS

SUMMARY OF RECOMMENDATIONS

Investigation of Structural Integrity of, and Impact of Vibration and Noise on Buildings at a Segment of Tbilisi-Rustavi Road Project (Section 2, km 5,2-6,9)

March, 2015

San Dona' di Piave (VE) 30027 - galleria Leon Bianco, 14 scala C
tel. 0421 330350 – fax 0421 330661 - e.mail nepsrl@nepsrl.com
Iscr. Reg. Impr. VE e C.F. 01186030936 - P.IVA 03304690278 - Cap. Soc. i.v. € 10.000,0

Introduction:

Below is the Summary of Recommendations based on the analysis provided in Parts 2-5 of FINAL CONSOLIDATED PROJECT COMPLETION REPORT AND RECOMMENDATIONS for the Project.

According to the work scope under the Terms of Reference and based on additional findings the recommendations below are provided on:

1 - **FEASIBILITY OF CUTTING BUILDING # 1** (Part 2 of the Consolidated Report)

2 - **ASSESSMENT OF VIBRATION IMPACT AND ITS RECOMMENDED MITIGATION AND MONITORING - DURING ROAD CONSTRUCTION AND ROAD OPERATION**

3 - **ASSESSMENT OF NOISE IMPACT (DURING ROAD EXPLOITATION) AND ITS RECOMMENDED MITIGATION**

4 - **RECOMMENDATIONS BASED ON FINDINGS IN ADDITION TO THE SCOPE OF WORK**

San Dona' di Piave (VE) 30027 - galleria Leon Bianco, 14 scala C
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SUMMARIZED RECOMMENDATIONS

1. FEASIBILITY OF CUTTING BUILDING # 1

Cutting of the building is technically possible and after possible cutting, the vibration impact during construction and road operation will not cause the risk for the structural integrity of the building, however, the risk of collapse of the remaining part of the building in case of even low/moderate amplitude seismic activity will be unacceptably high. Therefore, dismantling Building #1 is recommended. (See pg. 5-6 of the Part 2, FINAL CONSOLIDATED PROJECT COMPLETION REPORT AND RECOMMENDATIONS for more details).

2. ASSESSMENT OF VIBRATION IMPACT AND ITS RECOMMENDED MITIGATION AND MONITORING

2.1. VIBRATION IMPACT DURING CONSTRUCTION

A. ASSESSMENT OF THE LEVEL OF IMPACT

i) Impact on Buildings:

- In general, according to modeling performed, and assuming that no other heavy equipment and sensitive construction method (e.g. explosions) than provided in the Terms of Reference for the Project will be used in the Construction Works - vibration produced during construction works will not cause the risk of collapse or damage of the buildings (See Part 4, FINAL CONSOLIDATED PROJECT COMPLETION REPORT AND RECOMMENDATIONS for more details).

- However, clearly, there is no guarantee whether voluntary additions to the buildings described in Part 2 of the FINAL CONSOLIDATED PROJECT COMPLETION REPORT AND RECOMMENDATIONS, will not collapse during construction works. Those voluntary additions are unevenly distributed and realized by different types of materials. They show very thin bearing structures, mostly the metal ones, showing important bending and flexures. The assembling of the elements forming the enlargements show many faults: the cements is very poor, the aggregates have different sizes and most important, it clearly appears that no vibration was done during the pouring of the cement mixture. The reinforcements rebars are not protected and there are several detachments of weathered and damaged concrete slabs.

San Dona' di Piave (VE) 30027 - galleria Leon Bianco, 14 scala C
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To avoid this risk, these voluntary additions should be either removed or reinforced. Because removal of these additions doesn't seem to be a preferred option, reinforcement of the existent voluntary additions should be planned and supervised by a qualified engineer and implemented according to engineering design created. These works will not require long period of time and the cost of reinforcement will depend of the solution selected.

- It should be taken into account that all buildings have a very bad diffused and heavy degradation; the total absence of any type maintenance during their life has lead to important deterioration of all construction materials with the consequence of corrosion and expansion of the rebars with blow out of concrete, water infiltrations, detachment of plaster, et similar indications of very poor state of conservations.

- In case of claims of the building inhabitants for alleged damages during construction – the database of the Inventory of the Premises should be referred for the condition of the premises before the start of construction works.

- There are no special restrictive recommendations for the use of equipment listed in the Terms of Reference for the Project due to the short period of use of the most important/sensitive earth moving machineries. Roller-compactor, rubber mounted compactors should used and this machinery cannot be substituted by any other one or methodology due to the importance of compaction for the durability of the road basement. A good compaction is the key for a good durability. Compaction works will last, in the area of interest for a max of 2-3 days and during this period the main disturbance will be the noise.

DISCLAIMER NOTE 1 – FOR CONSTRUCTION PHASE VIBRATION IMPACT: The conclusions and recommendation provided in this FINAL CONSOLIDATED PROJECT COMPLETION REPORT are valid under the assumption that the construction company that will implement the road construction works will use the equipment and the construction methods indicated in the road detailed engineering design documents. Thus, it is recommended that MDF notifies the construction company in charge and gets the written acknowledgment response from it stating that should the construction company decide a) use other heavy equipment than in the project design documents; b) use any other construction/soil removal methods than in the project design documents; and c) conduct soil works outside the areas indicated in the road detailed engineering design.

San Dona' di Piave (VE) 30027 - galleria Leon Bianco, 14 scala C
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ii) Impact on building residents:

Although, assessing of the impact on the Residents of the Project Buildings was not a working task of the work scope of the project, Project Team performed this task to ensure conformity with the International Standards (at no additional cost to the Project Budget). As the result, it can be concluded that:

- The residents of all Buildings will experience disturbance from vibration during construction works. The vibration impact in the Buildings 2 and 4 during construction will be above the threshold of the Standard DIN 4150-2 by 1.50-2 dB (insignificant difference) and will be sensible. Maximum vibration levels during road operation (still in conformity with international standards will be observed in Buildings 2 and 4.

  However, such disturbance is unavoidable during construction and the duration of this disturbance during Construction Works hours will be limited to the period of time when Roller Compactor and Pneumatic Hammer will be operating. There is no other recommendation to this problem than the following: In order to minimize complains by the building residents regarding vibration during Construction Works, it is recommended that MDF, Supervisor Consultant and/or its contracted construction company (whichever convenient according to Georgian law and Contracts MDF has with the Supervisor and Construction Company) inform the residents of the expected disturbance and assure them that the vibration will not cause any safety risk to them.

B. RECOMMENDED MITIGATION MEASURES

NONE

San Dona' di Piave (VE) 30027 - galleria Leon Bianco, 14 scala C
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C. RECOMMENDED MONITORING MEASURES

- It is recommended to set a plan of monitoring of Buildings 2, 3, and 4 with accelerometers installed on foundations and structures.

  Monitoring should be set up and maintained by seismic accelerometers positioned according the following scheme:

  - One sensor on the foundations
  - One sensor on the intermediate floor
  - One sensor on the last floor of the building

  Monitoring should be maintained for the entire duration of the works in proximity of the buildings, and for a minimum of 5-6 months.

  Data recording should be continuous and should provide frequency peaks in form of velocities as indicated in standard DIN 4150-3.

- Building # 6 should be monitored by a combination of measurements of vibrations and displacements. This is deemed necessary, due to the special work to be done in proximity of this building by compaction roller because of the typology of the soil composed by filling materials. The displacements should be measured by sensors of linear displacements or inclinometers linked to a control unit for continuous measurements.

  Monitoring activities should also verify if the existing fissure pattern, mapped during the building survey, is still active, will be rejuvenated because of the activities and for a general study of the effects of works on the fissure network.

  The building manifests a foundational subsidence at the southwest corner (see picture # 10), this type of subsidence ("sinking" into the soil) is clearly visible by the trend of cracks in the external walls. In order to evaluate whether this subsidence is exhausted it is advisable to put in the work some of fissuremeters with the purpose of monitor and verify whether the problem is still in progress or has run out. This is very useful because the activities planned during the construction of the Road may amplify this phenomenon.

  Monitoring time in this case have to be long at least 12 month (better 18 months).

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- It is assumed that permanent monitoring of the use of equipment, construction methods and area of soil works will be performed by MDF of its Construction Supervisor company.

2.2. VIBRATION IMPACT DURING ROAD OPERATION

A. ASSESSMENT OF THE LEVEL OF IMPACT

i) Impact on Buildings:

- During Road Operation there will be no impact on buildings that could result in any damage.

ii) Impact on building residents:

- Except the Building # 2, the vibration impact on residents during road operation will be under the thresholds of the standard DIN 4150-2 for all buildings since the level of vibration is under the threshold for any spot farther than 15016 m. from the Road.

- Vibration level impact on residents in a part of the Building #2 will be over the permissive threshold in case road operation speed in above 90 km/h.

DISCLAIMER NOTE 2 – FOR ROAD OPERATION PHASE VIBRATION IMPACT: The conclusions and recommendations provided in this report for impact of vibration during road operation on the residents are valid under the assumption that the construction company n charge of road construction will fully abide by the requirements of the project design for soil compaction and concrete works. In this case, according to modeling performed, vibration levels will be in the permissive range of international standards.

B. RECOMMENDED MITIGATION MEASURES

- Mitigation measure for a part of Building # 2 would be to have road operation speed not to exceed 90 km/h.

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C. RECOMMENDED MONITORING MEASURES

- In case of MDF interest, as an optional measure (not strictly recommended) – vibration sensors could be installed in Building # 2 to monitor vibration coming from the operational road for 2-3 months after commissioning and opening of the road.

3. ASSESSMENT OF NOISE IMPACT (DURING ROAD EXPLOITATION) AND ITS RECOMMENDED MITIGATION

A. ASSESSMENT OF THE LEVEL OF IMPACT

As requested by MDF, noise impact modeling was performed for two road speed limit scenarios 80 km/h and 60 km/h. As the result:

- In case of 80 km/h speed limit scenario, the type of pavement as in the current engineering design, and no mitigation measures applied – the expected level of noise from Road Operation is above permissive threshold of 65dB (Georgian National Standard confirmed by MDF) – maximum noise level is 75 dB (for Buildings # 2, 3, 4 and 5)

- In case of 60 km/h speed limit scenario and the type of pavement as in the current engineering design, and no mitigation measures applied – the expected level of noise from Road Operation is above permissive threshold of 65dB (Georgian National Standard confirmed by MDF) – maximum noise level is 70-75 dB (for Buildings # 2, 3, 4 and 5)

B. RECOMMENDED MITIGATION MEASURES

- Mitigation measures are required to reduce the expected noise levels (in case of any of the two speed limits considered by MDF (80 km/h or 60 km/h) to buildings for Buildings # 2, 3, 4 and 5. For the rest of the buildings noise impact will be under the threshold at any of the two considered speed limits

- Modeling results show that an intervention (costly mitigation measures) on buildings windows and facades, or through changing type f road pavement could be avoided. Instead, the conformance with the threshold of

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permissive noise level (65 dB) can be achieved through designing proper type of noise barrier wall. Accurate and precise design of sound barrier wall, its position and shape, is an absolute requirement for success to reduce noise propagation not only in horizontal plane but also in vertical plane as well, and as the result to meet standard requirements.

- It is recommended that, as suggested by MDF itself, because the Project Team has detailed knowledge of the site and the problem including performing modeling and running different scenarios at the model – the same team provides MDF with the service of i) selecting the most optimal type of the noise barrier, and ii) providing precise location and the length of the noise barrier that must be installed. This service would be a logical continuation of the previous task and can be accommodated in the additional work scope.

- As a recommendation for MDF to consider, the work on noise barrier could be continued even further to include also the design of the noise barrier wall.

4. RECOMMENDATIONS BASED ON FINDINGS IN ADDITION TO THE SCOPE OF WORK

Geolelectric field investigation revealed a saturation of the soil layers close to Buildings # 2, 6 and 7 - most likely the result of leaking pipes (shallow water is found only next to the local water piping). For details, please see pages 5-7 of Part 3 of the FINAL CONSOLIDATED PROJECT COMPLETION REPORT AND RECOMMENDATIONS. As the result, the following actions and approaches are recommended:

- Identification of water leaks: It is highly advisable to make a preliminary search of water leaks, to map leaking points and to present these evidences to the water company. This quick and routine work should be done by a third party consultant not associated with the water Company to avoid any further claim from the company and the population. This task can be easily included in the additional scope of work for the Project. The task is not expensive, takes short period of time and the Project team includes experts with 10s of thousand kilometers of the similar work done worldwide.

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- Timing for water leak identification activities: It is imperative that this work is done PRIOR to the commencement of Construction Works of the road.

- To avoid legal and financial costs and safety risks: Identifying and eliminating water leaks is absolutely necessary for the following pragmatic (financial and legal) reasons in MDF interest:

    - Water leaks and resulting water saturation of building fundament is a threat to structural integrity of Buildings # 6, # 2 and # 7
    - If the leaking pipes are not fixed – vibration during construction and after, during operation of the new road will only increase the leaks (as it is always the case in practice) which will only increase the risks to the buildings exposed to the water saturation from leaks
    - If leaks are not documented before the start of construction, when the leaks increase during construction, and also if/when the leaks will cause even more damage to the affected buildings than now – the owner of the pipeline (GWP utility company) may have the pretext for a legal case (at least formally) against MDF for causing the damage to GWP assets (which largely exist before start of the construction(!)). Also, in case of building damage through leaks – GWP will try legally not to accept the responsibility and to direct it to MDF (as it is usually the case in similar situations worldwide).
    - If the leaks are identified before the start of construction (takes several days of work using compact special equipment and 1-2 specialized workers) – then MDF will not have any legal proof that it was not the road construction project that created leaks. Pragmatically better scenario for MDF is to identify leaks now and have GWP implement and finance fixing the leaks as soon as possibe before the start of construction (these works will not take long time).

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