CHAPTER TWO
2 LITERATURE REVIEW

2.1 Southern expressway

Southern expressway will pass through a significant part of the urban/ rural areas of western and southern provinces and in doing so affects many different communities. The social and demographical profile of the project area has a strong contrast between established suburban and rural areas and significant new areas for residential development. The occupational mix for the project area indicates higher percentage of agricultural based and also to some extends working on government and private sectors. Public transport is the dominant mode of transport in this project area while considered as the low socio-economic area with compared to the country.

2.2 Feasibility study

A feasibility study should be done by suitable experts (engineers, Economist, Environmentalist, Sociologist, etc...) before implementing any project to evaluate economical and social returns from the project. In addition environment impact assent also be done by the environmental specialist to minimize public hazards and environmental problems. After finalizing these reports a team of experts should study report and should be taken a decision for implementing the project.

Then these experts are concerned with works developed to protect and promote public health, improve the environment, and prevent degradation of land, water and air. Their practice includes surveys, reports, designs, reviews, management, operation and investigation of such works.

The objective of these works are protecting public health and controlling environment. Have to deals with treatment and distribution of water supply, collection treatment, control of pollution in surface and underground waters, limitations on exposure to radiation, limitations on noises and other environmental factors affecting the health, comfort, safety and well being of people and also environment.
The users of these reports and others take necessary decisions for continuing work or suspend work. Therefore accuracy of information is very important for all parties. The objective of preparing these reports is minimizing pollution, other environmental problems and overcome public matters.

After get approval from authorized institutions and take necessary precautions to prevent hazards construction can start. If construction management ignores these rules given by authorities they can suspend the work. Also they can take court actions against the construction.

But we cannot get 100% accurate solutions. So while doing construction we have to consider about public and environment. Sometimes we have to take mitigation actions to overcome ongoing issues which are occurred while construction progresses. Vibration due to construction activities especially in blasting and compaction is one of the major issues in southern expressway.

Earthborn vibration from vibratory compaction equipment can be described as single frequency continuous vibrations. Human perception of such ground vibrations is subjective and depends upon a number of factors. Damaged to structures causes by these earthborn vibrations can be categorized as either architectural or structural. Architectural damage is superficial damage such as hairline cracks in plaster walls or ceilings. While catastrophic damage to buildings from construction operations is always possible in nearby houses in southern express way .Some structural damage such as separation of masonry blocks and cracking in foundations may occur in cases where earthborn vibrations exceed threshold levels.

Central Environment Authority (CEA) has proposed vibration limit criteria, some intended to mitigate damages to structures and to limit human annoyance.
2.3 What is social impact assessment?

Social impact assessment has been applied in Sri Lanka to many provincial and federal projects and programs, including proposed energy generating stations, electricity transmission facility and highway construction assessments. More recently, a greater emphasis has been placed on SIA of the planning, design, construction and operation of proposed major roads projects.

Social impact assessment is a process of analyzing, predicting and evaluating the future social and economic effects of proposed policy, program and project decisions and actions on the well-being of people, and their businesses, institutions and communities. Its goal is to protect and enhance the quality of life by ensuring that potential socio-economic impacts are minimized and sound environmental decisions are made.

Social impact assessment involves identifying: significant potential positive and negative changes in peoples' cultural traditions and lifestyles, their physical and psychological health, their families, their institutions and their community. And, it identifies ways of avoiding, mitigating, enhancing or managing those changes (monitoring and impact agreements).

Importance of Social Impact Assessment:

- Predicts the nature and size of potential negative and positive effects on individuals, businesses and communities;
- Develops and implements appropriate recommendations and impact management measures to avoid or decrease potential negative socio-economic impacts and enhance positive impacts;
- Identifies net social and economic impacts occurring after mitigation measures are applied, including roadway routing, design and operating conditions; and, Helps resolve public issues by working with the community to address the potential impacts.
The impacts on people, their community and way of life can occur during project planning, construction, and the "operational" phase when the roadway is in use. The impacts result from the introduction of specific project characteristics (e.g. divided highway, length of construction) and the local community and individual's response. This response depends largely on the community and individual characteristics (Example: level of automobile travel, community satisfaction). Although each situation presents some unique potential impacts, the following list illustrates the types of socio-economic impacts that could occur.
2.4 Ground vibration

Vibrations from pile driving and dynamic compactions are likely to be the largest vibrations caused by the construction. However, as the exact method of piling and location of dynamic compaction have both yet to be finalized, it is recommended that predictive models be used to determine the suitability of any piling and dynamic compaction rigs proposed for the available separation distances between where the construction activity is planned to take place and nearby buildings. These predictive models allow ground-borne vibrations to be estimated from drop mass and drop height.

Both these activities will have to be specifically addressed in the vibration mitigation plan, should it be decided that dynamic compaction and/or drop weight piling can be employed in the construction of the Southern Expressway project. It is also recommended that field measurements be made whenever both these types of construction activity take place to confirm the vibration levels predicted. This will minimize the likelihood of any structural damage being inflicted on existing buildings. If applicable, vibratory piling methods should be adopted as this will significantly reduce the likelihood of structural damage arising from piling operations.

2.4.1 Nonlinear and chaotic vibrations of dynamic compaction machines

Figure 2.1 shows the simple, non-linear soil-drum model for vibratory rollers and plates; this model is valid subject to the proviso that the excitation frequency is well above the resonance frequency for the frame-suspension elements. In this case, the static weight of the frame may be regarded as force acting statically on the vibrating mass. More advanced models take account of the horizontal and rotary movements as well as the frame vibrations for vibratory rollers, oscillation rollers and rollers with directed excitations.

The model in Figure 1 has been validated many times in practice, not only on tandem rollers for asphalt compaction but also for soil compaction with single-drum vibratory rollers. After adaptation to the geometry of a directed excitation, the present model can also be used to describe the nonlinear and chaotic vibrations of vibratory plates, trench rollers and rammers.
The essential nonlinearity of the soil-drum system arises due to the periodic loss of contact between the vibrating mass of the compactor (which is subject to circular excitation) and the surface below it, as soon as the maximum soil reaction force \( F_S \) becomes larger than twice the static weight of the total mass of the machine. In the case of vibratory plates and rammers, this loss of contact is necessary for continued movement.

In analytical terms, the steady-state dynamic behavior of the soil-machine system from figure 1 can be described with the help of the equation of motion according to:

\[
F_S = (m_f + m_d) g + m_e r_e \Omega^2 \cos (\Omega t + m_d x) \\
\]

Where:

- \( F_S \) = soil-drum-interaction force (kN),
- \( m_d \) = drum mass (kg),
- \( m_f \) = frame mass (kg),
- \( x_d \) = vertical displacement of the drum (m),
- \( m_e r_e \) = eccentric moment of unbalanced mass (kgm).

The dot notation signifies the differentiation with respect to time.

The soil-drum interaction force can alternatively be written

Where:

- \( k_S \) = soil stiffness (N/m),
- \( c_S \) = soil damping (Ns/m).

Where:

- \( \phi \) = phase lag between the generated dynamic force and the part of drum displacement with frequency \( f \) (°). Depending on the operational status, the vibration displacement has one or more frequencies:
Permanent drum-ground contact, linear: \( i=1 \)
Periodic loss of contact, nonlinear: \( i=1, 2, 3 \) (Overtones)
Bouncing/rocking, sub harmonic: \( i=1/2, 1, 3/2, 2, 5/2, 3 \)

Figure 2-1 Analytical model of vertical vibration of a single drum roller (circular excitation).

This model is also valid for vertical deflection of vibratory plates (directed excitation)
2.4.2 Damage to the buildings caused by ground vibrations generated by vibratory compactors

Vibratory compactors generate ground vibrations which can be felt long distance from the machine. The same type of ground vibrations are produced by road traffic, pile driving, sheet driving and blasting operations. Ground vibrations over a certain magnitude can cause damage to buildings and other constructions.

A vibratory compactor is operating on the ground generates pressure (compression) and shear waves called body waves as well as the surface waves (primarily Rayleigh waves). The surface waves and the wave types which are of primary concern for structures on or near the surface of the soil. The amplitudes of the surface waves decreases rapidly as the distance from the vibrator increases, to a large extent depending on the decrease in wave energy caused by the circular propagation of the waves.

A wave motion is characterized by frequency and amplitude. It has been generally accepted that the risk for damage is determined by the maximum velocity of the ground vibrations, which can be calculated according to the formula.

\[ V = 2\pi f \cdot s \]

Where;
- \( V \) = maximum velocity during wave motion mm/s
- \( f \) = frequency, Hz
- \( s \) = amplitude, mm

As an approximate and general rule, it has been found that ground vibration generated by compaction activities with a velocity higher than 2 mm/s (on the structure foundation) cause damage to the buildings. Also note that the vibrations in building foundations are less than the surrounding ground. If the wave velocities in the ground, just outside and inside a building are measured simultaneously, the wave velocities in the building foundation are 2 to 5 times lower. When Vibration is measured during in compaction activities, the value of the vibration can be change place to place along the highway trace. Following factors are mainly associated with the vibration levels.
• Types of the soil and soil profiles vary to a large degree. The strong vibrations can be found in silt and clay with high water content.

• Ground vibrations may be stronger than during dry conditions while compare with the wet condition of the soil.

• Types of foundations, as well as structural designs and condition of the building can be affected for the vibration level.

• Resonance phenomena in different parts of the building such as the chimney -shift may increase the risk of damage to the building.

• If the stress limit in a material is already approached, as it often the case in plastered walls, very small additional stress may cause damages.

• Start and stop of the vibrations temporary increase the ground vibration as the resonance frequency of the system vibrator soil has to be passed. Resonance vibrations in building structures can also be developed. The vibration should not start or stopped near the buildings.

2.5 Vibration Control and Monitoring

Vibration producing activities (such as blasting, pile driving, vibratory compaction, pavement breaking or operation of heavy construction equipment) are common in construction projects. Four levels of vibration control can be provided on a project, depending on things such as structure susceptibility to damage, proximity to vibration producing activities, local concerns, or district policy. The "levels" can briefly be defined as follows:

Level 1: No specific mention in contract of possible problems or controls. On a statewide basis, this is most common for minor or small quantities of pavement breaking or pile driving, when they are not in proximity to occupied structures or sensitive receptors.

Level 2: Alert contractor to possible problems by brief description in the special provisions. Vibration levels and monitoring are at the discretion of the contractor, and the contractor is responsible for all damage caused by his activities.
Level 3: Detail concerns and require the contractor to do a prescribed condition survey and to employ a qualified vibration specialist to establish a safe vibration level and monitor the vibrations. As an alternative, a vibration level may be set by the Department, such as the “Geological survey and mines bureau”. It may also be appropriate to use experienced based vibration criteria. The contractor is still responsible for any problems.

Level 4: State takes lead role and has consultant(s) do a damage susceptibility study to establish vibration control limits, and a preconstruction condition survey for each structure. The State also takes responsibility for vibration monitoring during construction to insure compliance with vibration control limits. At this level, the State assumes some responsibility for damage to structures if the established vibration limits are not exceeded by the contractor. The degree of responsibility depends on the vibration specification - most vibration specifications are aimed at avoiding structural damage, leaving the contractor responsible for any cosmetic damage (e.g. plaster cracks, broken windows, etc.) and keeping residents/occupants informed and "happy”.

Table 2-1. Maximum Permissible Vibration Levels

<table>
<thead>
<tr>
<th>Activity</th>
<th>Frequency/type</th>
<th>Permissible Vibration in PPV (mm/Sec)</th>
<th>ABOP dB (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction activity / vehicle movement</td>
<td>10 – 50 (Continuous)</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Rock Blasting with multi bore holes and with delay detonators</td>
<td>Impulsive</td>
<td>5.0</td>
<td>120</td>
</tr>
</tbody>
</table>
2.6 Cracking in Buildings

Cracking first occurs in buildings immediately after construction or over a period of several years, depending upon the methods and materials used in construction and change in ground characteristics caused by, for example, the removal of trees. Buildings have different life spans or time periods before deterioration or damaged occurs. This time period depends upon the stresses to which the building has been exposed as well as the residence of the building materials to physical and chemical effects.

Heat, moisture, settlement, occupational loads, material creep and chemical changes all cause movements in the building, in an optimized design, the buildup stress concentrations in the structural elements should be minimized. If the design does not permit adequate relaxation of these stress concentrations, then cracks will develop which indicates where movement joints are required or alternatively where further support or reinforcement is needed. Thus cracks normally exist to varying degrees in buildings not subjected to vibration and are not in themselves, an indication of vibration-induced damage. There are many reasons why buildings crack are care is required to ascertain the true cause.

A building not exposed to major external disturbances such as vibration, there exist a time state of cracking due to natural ageing. This is natural cracking rate can be significantly increased by an external disturbances triggering cracks instantaneously, which can only be detected by a recovery of building cracks immediately before and after the disturbance. A small increase in cracks or crack length however should not be taken as damage due to any imposed vibration. Buildings so expand and contract preferentially along existing weaknesses (cracks) between day time and night time and also seasonally. This continually varying expansion and contraction will return normal repair and repainting to the previous cracked state within several years or even months.

Wall and ceiling lining material rather than the main building components are often the most sensitive to imposed vibration. For cracking to occur, the vibration induced strain so that the critical strain of a wall covering material is exceeded. The lowest critical strain is associated with old plaster and lath walls while the paper backing on gypsum-type wallboard has the highest resistance to imposed strain, although cracks can frequently occur at the joints between boards.
2.6.1 Age and existing condition of building

The age and existing condition of a building are factors to consider in assessing the tolerance to vibration. Older buildings may have soft mortar joints, simple footings or poor cross-bracing. Arches may be effectively articulated off the main structure. Modern buildings have limitations on deflections, deviations, inclinations, curvatures or widths of cracks allowed at the design stage. Guidance is available with respect to cracking for modern buildings according to the building material involved whether the cracks are surface cracks or through-cracks, whether they are likely to open further or close, whether they are repairable or capable of being covered by decoration, whether water penetration is a factor and the probable attitude of persons affected, in view of the intended use of the building.

2.6.2 Building damages due to soil compaction

Depending upon the type of ground, ground vibration can cause consolidation or densification of the soil, which has been known to result in differential settlement and consequent building damage. Loose or especially water-saturated cohesionless soil is vulnerable to vibration which may cause liquefaction. It has been shown in laboratory tests that there can be a rearrangement of constituent particles at strains of 0.0001 and this becomes marked at strains of 0.001. Such soils, which may have shear wave propagation velocities of around 100 m/s start to become vulnerable at peak particle velocity values of about 10 mm/s. The damage to the soil structure is then a function of the number of cycles of straining. The loading transmitted to the soil though the foundation may reduce the vulnerability of the soil to such damage, but there are cases where the acceptable vibration limit may be set by consideration of soil-structure interaction, rather than distortion or inertial response of the building itself.