DESIGN, CONSTRUCTION AND ACOUSTIC PERFORMANCE OF A SOUND-PROOF ENCLOSURE FOR DIESEL GENERATOR-SET

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ABSTRACT

This paper presents the design and construction details of a sound-proof enclosure for housing 20 KVA diesel generator-set. As the generator had to be installed close to the hospital building, it was desirable to reduce the transmission of noise by housing the generator in such an enclosure. The diesel engine being an air cooled one, it was essential to supply fresh air into the enclosure for its cooling. Forced inflow of air is provided through an inlet duct located in such a way that the incoming fresh air is thrown close to the inlet of cooling fan of the engine. The high velocity air stream, which heats up while passing over the engine head, escapes to the atmosphere through a rectangular outlet duct with enlarged inlet that receives hot air from the engine. The air ducts were designed specially and have been provided with acoustic lining for sound absorption. The masonary enclosure has been provided with double glazed fixed windows and double doors. The exhaust pipe of the engine fitted with a muffler has been taken out through the enclosure wall facing away from the hospital. Acoustic performance studies conducted in terms of attenuation provided by the enclosure at different frequencies have also been presented and discussed. The noise control measures adopted for building the sound-proof enclosure have been found to be quite effective as the noise levels inside the hospital building are now within the acceptable limits.

1. INTRODUCTION

Many a time there is a need of power generator-set which has to be installed as a standby measure in the event of power cuts or break-downs. The diesel generator-sets that are locally available are quite noisy and invariably require a sound proof enclosure. An existing enclosure (or a building) can be made sound-proof (Ref.1,2) but it requires a lot many changes involving considerable labour and material cost. It is thus always advisable and

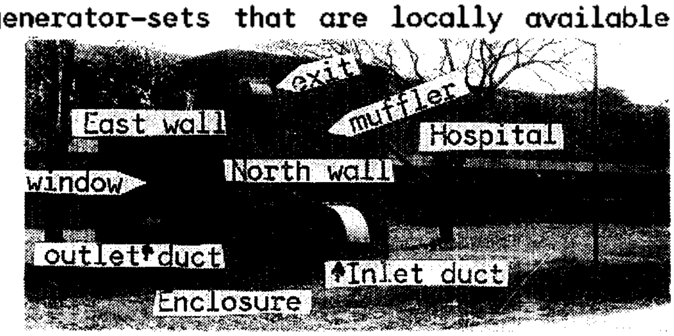

Fig.1. A view of the generator enclosure

economical to introduce all the noise control measures right at the design stage. One such enclosure has been constructed (Figure 1) to accommodate 20 KVA diesel generator-set to supply power to the Hospital of Punjab Agricultural University, Ludhiana (India). It has been designed by keeping in mind the noise level of the generator-set and the acceptable noise levels at the sensitive points. The basis for selection of the site and orientation of the enclosure have been described first and the acoustic design details are then presented with the help of Figures, but without going into the details of civil engineering design. Finally the results of acoustic performance have been presented and discussed. The noise levels recorded at the exposed facade of the hospital building and at the residential area conform to the acceptable limit of 40 dB(A) (Ref.3) in hospital rooms.

2. DESIGN AND CONSTRUCTION DETAILS

The use of diesel generator-set as a standby source of power is quite essential for hospitals in the event of power break-downs. The diesel generator sets locally available are generally very noisy and have to be installed on the premises of such buildings. Keeping in view the lanscape and architectural considerations, the present site and orientation (Figure 1)was selected for the generator enclosure

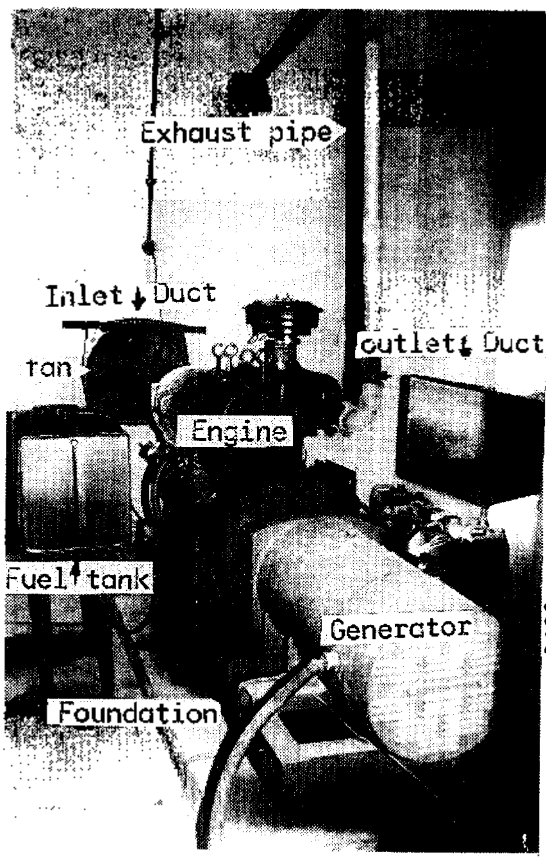

Fig.2. Interior of the enclosure

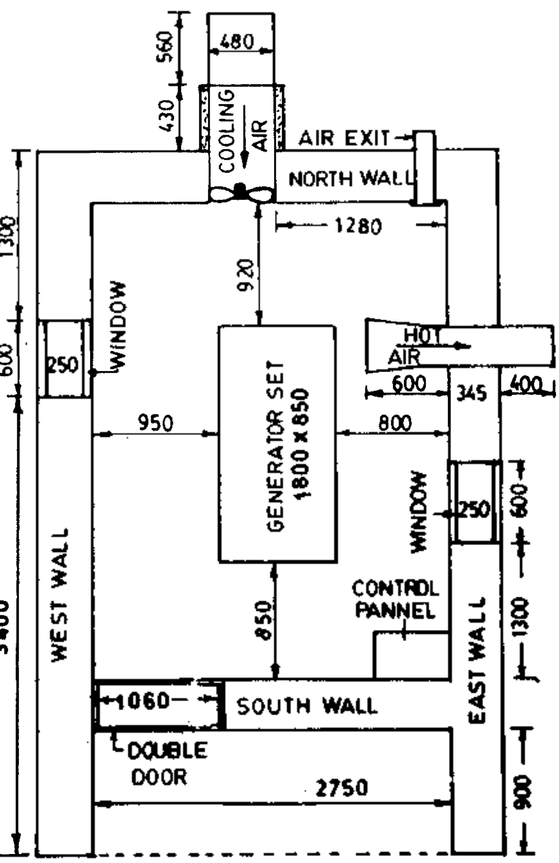

Fig.3. Plan view of the enclosure.

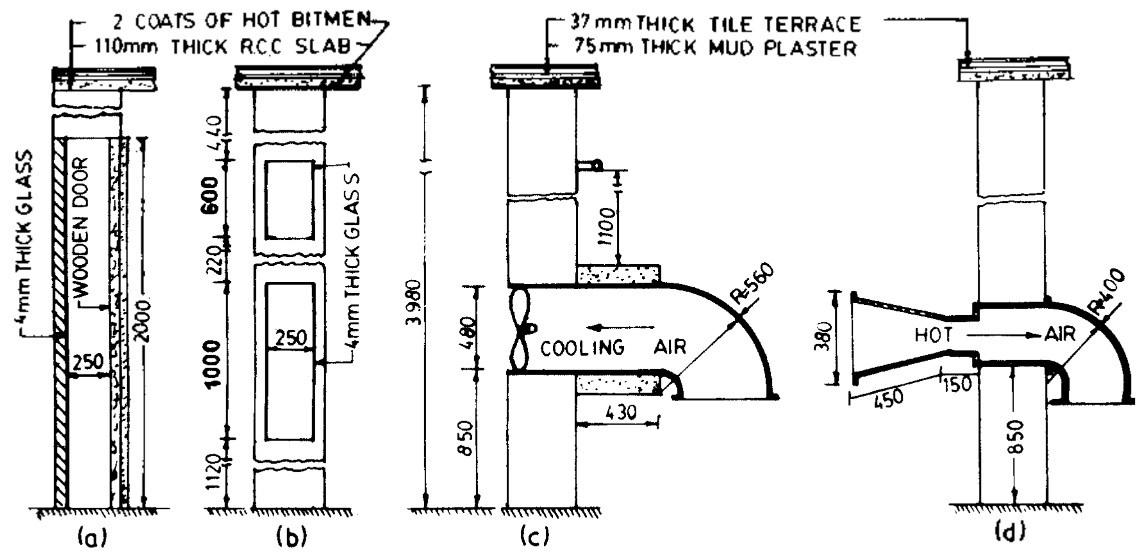

Fig.4. Details of double door (a), double glazed windows (b), inlet duct with fan (c) and outlet duct (d).

and the entrance to the enclosure had to be provided in its south wall. The generator enclosure measuring 2750 mm x 4050 mm internally and with R.C.C. slab roof at a height of 3980 mm from the floor has $1\frac{1}{2}$ brick (345 mm) masonary walls. There is 900 mm porch over entrance at the south side. The total thickness of the roof that includes RCC slab, Bitumen, mud and tile layers is 250 mm. The details of the interior of the enclosure are seen in Figure 2 and the construction details are given in Figures 3 and 4. The walls, roof and the foundations (not shown) are as per standard civil engineering design. For the enclosure to give best acoustic performance, not only its walls should have high mass per unit area but these should be continuous and uniform. Openings in a wall adversely affect its overall performance. The proportion of the wall area occupied by window glazing also has an appreciable effect on the overall performance of the wall. Fresh air is required not only for breathings of the engine but also for its cooling; especially when the engine is air-cooled like the one we have. Forced air circulation will require two openings, which can be in the same wall or in two different walls. The other opening which can be essential are the windows and doors. These have to be kept closed when there is forced circulation of air. Since we have to discharge the exhaust gases of combustion of the engine to the atmosphere, we have to take the muffler tailpipe out thıough one of the walls. A high performance muffler can be used that can attenuate the exhaust noise by any amount but it will not reduce the noise to an acceptable level without increasing the back pressure on the engine and hence adversely affecting its output and the efficiency. The least costly and still the most effective way of noise attenuation is by (i) increasing the distance between the source and the receiver and (ii) introducing the screening effect. Many a time there is a limit beyond which we can not increase the distance; but the screening effect can always be introduced at the design stage without much extra cost.

As shown in Figure 1, the south wall which faces the hospital building and being nearest to it (only 19.3 m away) should have been a solid wall but the entrance had to be provided in this wall as mentioned above. Double door (1060 x 2000 mm) has been provided with an airgap of 300 mm. 35 mm thick wooden door with sound absorbing panels fixed on its inner face is fitted inside and the 4 mm glass/steel door is on the outer side (Figure 4(a)). The doors are provided with rubber foam gaskets for making them air tight. The west wall which is also close to the hospital building is solid, except that a double glazed window had to be provided with 4 mm glass panes fixed 250 mm apart (Figure 4(b)). This wall is expected to give very good overall performance. The east wall has a window similar to the one mentioned above. Besides, it has an opening in the form of hot air outlet duct (Figure 4 d)). The location of this wall with respect to the hospital is such that it provides some screening effect to the noise radiated from it. The north wall is not only provided with the cooling air inlet duct (like the other duct) (Figure 4(c)) and a small air exit near the top, but the tail pipe of the muffler also comes out through this wall. The overall performance of this wall will obviously not be high. That is also not required, because it faces the play grounds, school building and the residential area that are sufficiently away. The inlet and outlet ducts are lined with sound absorbing material and their ends extending outside the enclosure are given downward bends. Noise attenuates considerably as it flows out of the ducts. Provision of such ductsw improves the performance of the walls as compared to when they have simple openings. The concrete roof, having additional layers of mud and tiles (Figure 4) and no opening through it, will perform well.

3. MEASUREMENT OF NOISE LEVELS

The noise levels of diesel engines measured inside the enclosure are normally around 105 dB(A), (Ref.2). The attenuation provided by the solid walls and the walls with certain proportion of area covered by windows and doors can be predicted (Ref.3). However, when the situations arise like that of the north and east wall which are fitted with small ducts having curved air flow passages, it is quite difficult to predict the overall attenuation provided by such walls. The commulative effect of the noise emitted by the exhaust muffler, noise transmitted through the wall and the cooling air duct coupled with the screening effect provided by the north wall, on the noise level recorded at the north facade of the hospital building, could not however be predicted precisely. It was therefore essential to measure the noise levels at various locations, both inside and outside the enclosure and at the windows and in the rooms of the hospital. Bruel and Kjaer equipment was used to measure the dB(A) noise levels and also to carry out the frequency analyses. Noise level was measured at ten different locations inside the enclosure with the double doors closed and it was found to vary from 104 to 106 dB(A). Frequency analysis of the noise levels above the engine was also carried out. Noise levels, dB(A), were measured at an interval of 2 m away from the enclosure in all the 4-directions.

Frequency analyses of the noise levels outside the north wall, south wall were conducted to find the attenuation provided by the doors and the walls at different frequencies.

4. DISCUSSIONS OF RESULTS

Noise level was recorded as 88 dB(A)at a point located 1 m away from the north wall and one meter below the muffler. It was found to attenuate to 52 dB(A) at the nearest wall of the residentail building. Noise level outside the east wall provided with the hot air outlet duct was recorded as 79 dB(A) and it attenuated to 58 dB(A) at the wall of the Community Hall, which is considered to be acceptable in view of the social activities normally held there. The noise level of 69 dB(A) just outside the south wall with both the doors closed was found to attenuate to 50 dB(A) at the nearst point of the hospital. The noise inside the room was 40 dB(A) with the windows open.

Figure 5(a) compares the noise levels at various 1/3 octave band centre frequencies recorded above the engine inside the enclosure, outside the north wall where the exhaust noise is predominant and out side the west wall where it is the minimum. The difference between the noise levels inside the enclosure and outside the west wall, obviously gives the attenuation provided by the solid wall which has a maximum value of about 60 dB at 1250 Hz. Attenuation provided by the solid wall at very low frequencies (upto 63 Hz)is quite low (upto 10 dB). An overall attenuation of (106-63 =)43 dB(A) has been provided by the 1½ brick

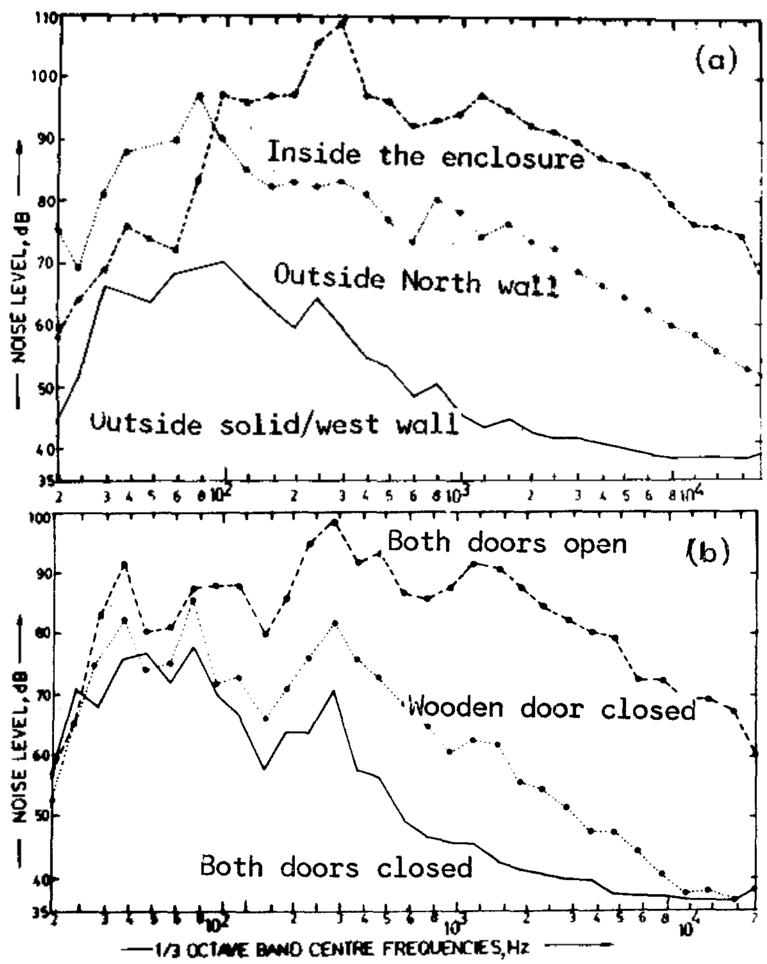

Fig.5 Frequency analyses of the noise levels inside, outside the north and west wall (a) and outside the double door/south wall(b) of the enclosure

(345 mm) masonary wall.

The noise levels recorded upto 100 Hz outside the north wall are more than the corresponding noise levels recorded inside the enclosure. This is partly because the low frequency noise from all the engine sources (other than the exhaust noise) is attenuated only slightly by the wall and partly because the low frequency exhaust noise not emitted inside the enclosure, is also not much attenuated by the muffler. Attenuation above 100 Hz varies between 15 to 20 dB. An overall attenuation of (106-88 =) 18 dB(A) has been provided by this wall. Figure 5 (b) compares the noise levels when (i) both the doors were open, (ii) only wooden (inner) door was closed and (iii) both doors were closed. Difference in noise level at the corresponding frequencies indicates that the attenuation provided at very low frequencies (upto 80 Hz) is quite low (upto 8 dB) for wooden door and upto 15 dB for the double door. Attenuation increases with frequency and it has been found to be upto 45 dB for the double door at higher frequencies. Bases upon the dB(A) noise levels, an overall attenuation of (101-69=)32 dB has been provided.

5. CONCLUSIONS

The sound-proof enclosure designed and constructed for the 20 KVA diesel generator-set, installed closed to the University Hospital, has proved to be quite effective in containing the noise. Acoustic performance of the inlet and outlet air ducts double glazed glass windows and the double door have been found to be quite satisfactory. Attenuation provided by the solid wall and the double door are 43 and 32 dB, respectively. Noise levels recorded at the exposed facade of the hospital are upto 50 dB(A). With the windows closed, the noise levels inside the room are of the order of 40 dB(A), an acceptable noise limit for the hospitals. Likewise the noise levels recorded at the nearby residential area and the Community Hall are also well within the acceptable limit. In summer, not only the windows have to be kept open but the fans and/or air coolers also have to be used, which generate noise that varies between 50 to 60 dB(A); a level above that of the generator noise recorded at the windows.

REFERENCES

1. A.S.Bansal, "Insulating an existing college building against traffic noise" Proceedings of Inter-Noise 81 held at Amsterdam, pp 401-404 (1981).

2. A.S.Bansal and N.S.Behniwal, "Sound-proofing and existing enclosure of a diesel generator-set," Proceedings of WESTPRAC-II 85 held at Hong Kong pp. 17-23 (1985).

3. L.L.Beranek, "Criteria for noise and vibration in buildings and vehicles", Noise Reduction Ed. L.L.Beranek. Mc Graw Hill Book Company Inc. N.Y.pp.514-538, (1960).