Design & Construction of Laser based Electron Acceleration lab building.

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Abstract

The paper highlights the salient features of building planning, design and construction for lab building for ultra-intense laser plasma interaction and laser based electron acceleration experiments at RRCAT. The multi disciplinary requirement coupled with stringent environmental conditions necessitates proper planning of space, safe and optimized design to satisfy the functional needs like equipment layout, man and material movement, structural stability, in-corporation of various services etc. Since the facility has radiation hazards, it is essential to not only have proper radiation shielded structure to attenuate the same below the permissible limits but also to ensure reliable operating facility.

The design of building is undertaken for stability which includes seventeen load combinations, provision for various services like thermal insulation and dust controlled environment etc. and also designed as an un-cracked section. The propagation of Laser beam from laser source to target area through an opening in concrete shielding wall has been planned as per the requirement of experimental setup. The design and construction scheme has been adopted to avoid micro cracks due to thermal stresses. The quality assurance plan included evaluation of in-situ concrete by conducting in situ Non-destructive tests in addition to routine tests on concrete mix.

BUILDING PLANNING

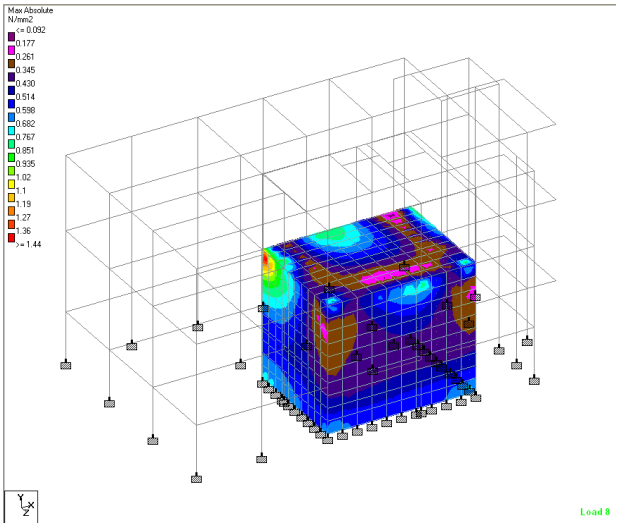
The laboratory has two important activities namely production of high power laser and experimental area. The high power laser lab and other labs are planned in such a way that the experimental area where radiation shielding is necessary is surrounded by laser lab and other facilities in three sides. In order to have flexibility of access & working in the radiation shielded area, one wall of vault is made by using interlocking concrete blocks. The pre-cast blocks partition with staggered joints and interlocking concept is not only gives structural stability but also ensures radiation attenuation due to zigzag pattern however wall thickness of interlocking pre cast blocks needs to be increased by 10% of the corresponding cast in situ concrete wall for radiation attenuation requirement. The other experimental labs and services are placed in the first floor above the shielding area. The experimental shielded area is the part of main building having a clean room to house the Laser, various labs and services. The service area adjacent to high power laser lab has been planned to install power supplies. This has reduced the heat load in lab. Fig-1 shows the Architectural plan of the building. The important features of this building are:

>Isolation of higher radiation level area from the labs with occupancy
>Radiation shielding design
>Standard construction practices for radiation shielded area
>Ventilation scheme for Radiation shielded vault.
>Equipment installation scheme
>Thermal insulation and finishes for dust controlled environment
>Appropriate method for heat dissipation in shielding concrete.
>Comprehensive planning of building as extension of existing building & utilization of common facilities and services

STRUCTURAL DESIGN

The experimental area has 1.0 metre thick concrete walls at all the three sides and concrete pre-cast block on remaining side. The building have been designed as RCC framed double storied and the shielded experimental area as RCC plates having thickness of 1.0 metre for all the subjective loads like Dead Load, Live Load, Earth quake load and temperature stresses. Various load combinations have been considered and structure is designed for the maximum stress combination. In seismic analysis the importance factor and the fire rating of this building are considered as 1.5 and 2.00 hours respectively. To avoid differential settlement in the experimental area, RCC Raft has been provided over hard strata having Safe Bearing Capacity (SBC) of 30 T/sqmts. The remaining area has been supported over soil strata having SBC of 20 T/sqmts. The structural design was carried out using computer aided design and the stress block obtained in the design is shown below.

Building Model & Stress Block



QUALITY ASSURANCE MEASURES

The design of Radiation shielded area though governed by the shielding requirement yet necessitate precaution for shrinkage cracks and clean joints to avoid streaming of radiation. The radiation shielding wall and slab being 1.0metre thick, were susceptible to thermal cracking due to temperature gradient. In order to obviate this problem, to obviate this problem, the pouring temperature of concrete is limited to a maximum of 23^0C by using ice cooled water and cooling of aggregates. Template forms were used to avoid clean joint and consequent radiation streaming. The pre-cast concrete blocks ensured flexibility of access & working in the radiation shielded area. The joints were green cut, cleaned using jet water and cement mortar 1:1 was applied before the next concreting is taken up. Concrete cubes of 150mm size were cast during construction to check the density and compressive strength of the concrete. Slump cone test were carried out check the workability of concrete to ensure proper compaction. Non-destructive tests using Ultrasonic pulse velocity and rebound hammer test are carried out at number of points in the wall and in the sample block cast during construction to check whether the concrete has any voids and some of the test results are tabulated below

Table 1: Results of Ultra Sonic pulse velocity test

Sr.No.	Travel path in cm	Pulse velocity in Km/sec	Quality of concrete
1.	40.0	4.7	Excellent.
2.	40.0	4.47	Good
3.	40.0	4.46	Good

Table 2: Results of Rebound hammer test

Sr.No.	Rebound number	Standard deviation	Compressive strength
1.	48,49,54	3.21	570Kg/cm2
2.	57,53,50	3.51	620Kg/cm2
3.	43,43,43	0.00	490Kg/cm2

CONCLUSION

The building design for the Construction of Laser based Electron Acceleration lab needs consideration of various services in addition to space design. Construction schemes are also required to ensure fulfilment of requirements of radiation shielding and other services. The requirement of such facilities being uncommon should be designed with utmost care in a comprehensive manner.

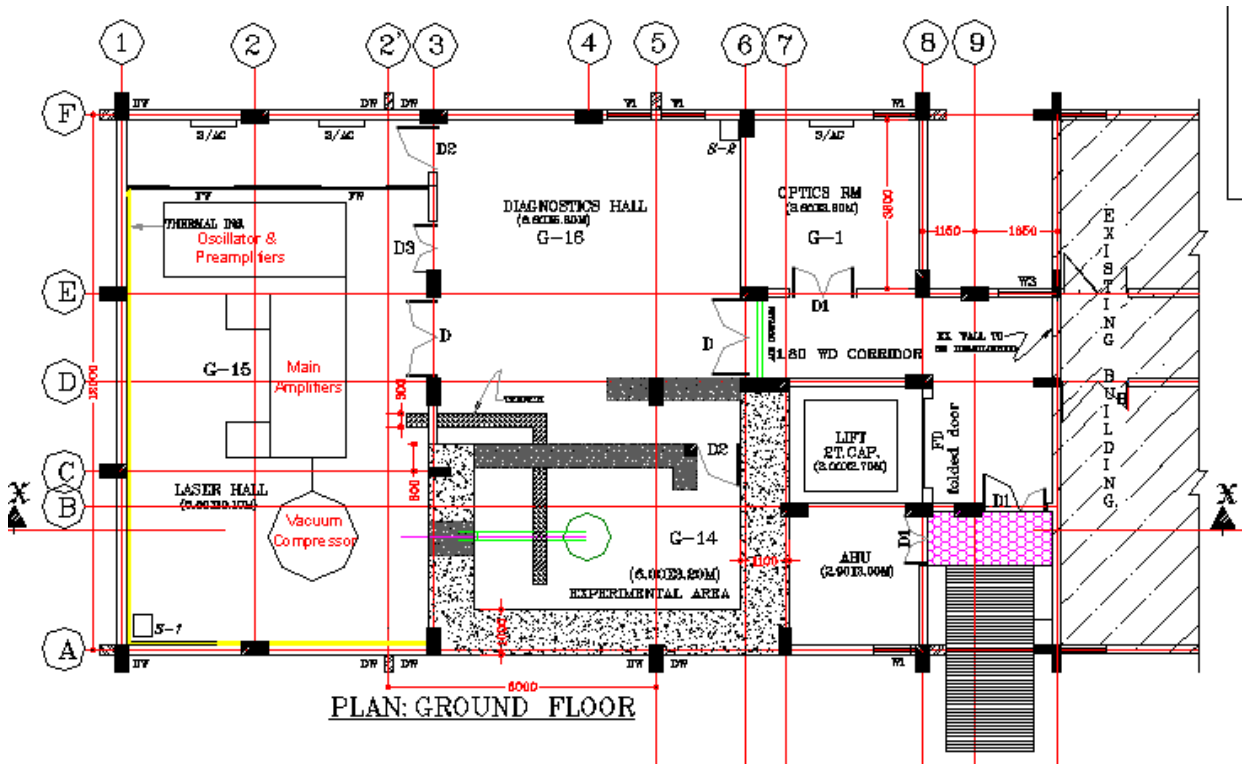


Figure 1: Architectural Ground floor plan of the building