# Delving

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### *Articles*



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# Sandbox: A Secured Testing Framework for Applications

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***Abstract***

As malware has become more sophisticated, monitoring suspicious malware detection behavior has become difficult. Recent threats have incorporated advanced obfuscation techniques that can evade being detected by endpoints and network security products. Sandboxing protects the critical infrastructure of the organization from suspicious code as it operates in an isolated and separate environment. It also facilitates information technology organizations in testing malicious code in an isolated testing environment for understanding its working within the system and to detect similar malware attacks more quickly.

***Keywords:*** Sandbox, Security, Malware, Cloud Sandbox, Appliance Sandbox, Evasion

## I. Introduction

A sandbox is a security platform for running unknown executables in a dedicated environment without the risk of affecting the production systems. Basically, sandboxes are virtualized environments that simulate live systems to ensure that the tested executable runs in way that is almost the same, if not identical, to the real environment. Sandbox systems allow the monitoring in an isolated environment of suspicious executable files while minimizing the risk of compromising live systems. Another important aspect of sandbox is that it minimizes human efforts in complex tasks like disassembling the executable to understand its purpose. This facilitates security administrator without extensive malware analysis training to perform a triage of suspicious files and only send confirmed malware for analysis.

Although malwares have been around since the early days of computers, the sophistication and innovation of malware has increased over the years. The latest ransomware has drawn attention to the dangers of malicious software, which can cause harm to private users as well as corporations, public services governments, and security institutions. To prevent this, malicious activity must be detected as early as possible, before it conducts its harmful acts which is a tedious task especially when dealing with new and unknown malware capable of virtually emulating entire end-user operating environments, a sandbox safely executes suspicious code so its output activity can be observed. Early security sandboxes could only scan executable files but advanced platforms are now able to scan Adobe Flash, JavaScript, and Microsoft Office files, among others. Cutting-edge sandboxing solutions today now provide tight integration into the rest of the security infrastructure. In this paper we have endeavored to review the concepts of sandboxing technique comprising the

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benefits of the technique, types and limitations.

## II. Literature Review

"Sandboxes are increasingly important building materials for secure software systems. In recognition of their potential to improve the security posture of many systems at various points in the development lifecycle, researchers have spent the last several decades developing, improving, and evaluating sandboxing techniques" [1].

Sandboxing is a software management strategy that separates applications from critical system resources and other programs. It offers an additional protection layer that prevents system from the adverse impact of malware or harmful apps. To test new programming code, software developers use sandboxes [13] In order to check possible malicious software, cybersecurity experts are using sandboxes. The sandboxes are used for safe execution of malicious code in order to avoid damage to the device, the network, or other devices connected [10]. Runtime sandboxes is actually instancing of virtual machines. High profile applications [3] like the Google Chrome browser, Internet Explorer Protect Mode, and Adobe Reader X employs sandboxing.

Unlimited system resources access and user data can be possible for an application without sandboxing as shown in Fig:1 and the other way around, a sandboxed application can only access its own sandbox's resources. A sandbox environment is a restricted space and memory area that includes only the resources needed by the software. If a program needs access to sources or files outside the sandbox, the system must explicitly give permission. For example, if a sandbox app is being installed in Operating system, a certain directory is created for the sandbox of the application. The app is provided with unrestricted write and read permission in that directory but no other files can be read or written on a computer storage device except where the system permits it.

Typically, sandboxing is extended to the most vulnerable components of the application. The sandboxed applications run with very limited and restricted privileges and uses DLL hooks and memory trampolines as required for certain Application programming interfaces (API). This means that the sandbox can examine and rewrite or block some system calls for malicious behavior.

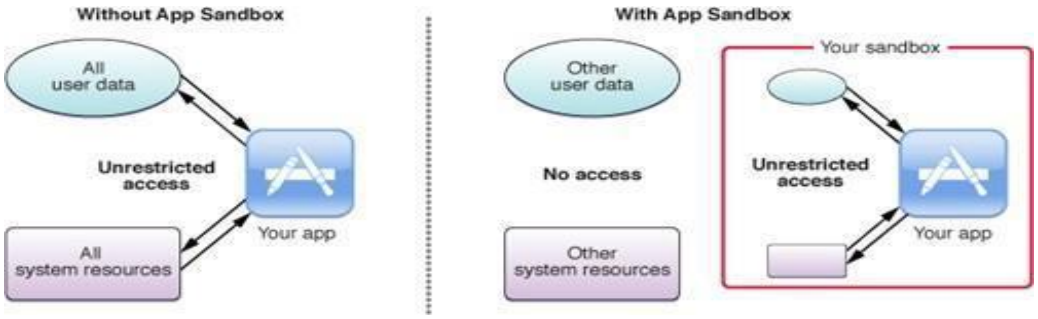


Fig 1: Resource access with and without sandbox

Google chrome browser is a perfect example. The software architecture of chrome is shown in fig 2. Due to Chrome's authors' focus on preventing exploits targeting the rendering engine and installing persistent host malware (the most common scenario for attacks) , they have chosen to just place only the rendering engine component in the sandbox and to allow other browser components to run unmanaged in the kernels browser[2].

Sandbox test detects malware proactively by running detonating code in an isolated and safe

environment to monitor the behavior and output activities of the code. Sandbox testing whereas traditional security measures are reactive and based on the identification of signature, which works by searching trends in known malware instances. Since only previously defined threats are detected, sandboxes add another essential security layer. Furthermore these defenses are only as good as the models which power those solutions even though the initial protection defense uses artificial intelligence or machine learning (signature detection is less), still the need of providing these solutions with advanced malware detection arises.

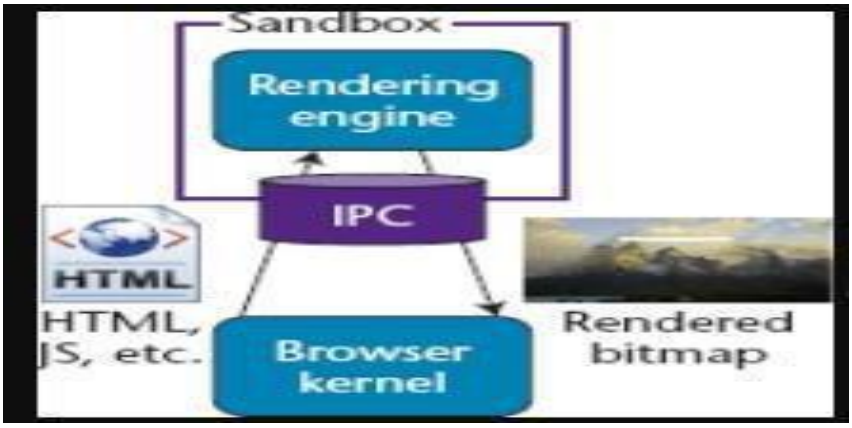


Fig 2: Google Chrome Security architecture using sandbox

## III. Sandbox Implementations

Many sandboxing solutions are available which can be more or less appropriate according to the needs of your organization. The implementation [3] of sandbox includes three important scenarios:

- Full Emulation System: The host machine's physical hardware including CPU and memory is emulated in the sandbox providing deep visible content and effect on program behavior.
- Operating Systems Emulation: The operating system but not the machine hardware is of end user is emulated in this implementation of sandbox.
- Virtualization: suspicious programs are contained using virtual servers.

## IV. Cloud Sandbox and Appliance Sandbox

A major classification of sandboxes that exists today is cloud based and appliance-based sandboxes. The traditional method of sandboxing, the appliance sandboxing requires an organization to make an investment in the equipment needed to provide virtual server machines and their deployment in office premises. The operation and maintenance of these virtual servers was costly and occupied large physical space as well. Today's sandboxing appliance solutions are costly and thus usually installed only in the data Centre. When users leave the network, they are exposed to new threats, since they cannot be followed by sandbox protection. Appliances sandboxing or organization hardware sandboxing tests those applications, files, or downloads without any data leaving the organization network. In that case remote workers are exposed to network threats and the appliance

sandbox goes blind when they are away from office or in transit. Appliance sandboxing, support limited investigation as malware has been known to hide in SSL traffic. If your software can not monitor all SSL traffic, threats can be broken through and exposed through hardware to the network.

Since cloud sandboxing has remote working benefits, backups and recovery benefits and cost cut for in-house hardware, physical appliances are being utilized less. Cloud sandboxing [11] means that in the sandbox, URLs, downloads or code are tested. Sandboxing on a virtual environment is entirely separated from the system or any other network devices. Potentially malicious files execution can still be unsafe for a business or personal appliance, being physically present and connected to the device. With cloud-based sandboxing, a costly instrument that requires maintenance, updates and ultimately depreciation is eliminated. A virtual server could be started in seconds once Companies wanting to deploy their cloud sandboxes decide a trusted provider and are ready with the requirements of virtual servers, memory and number of user slots they need.


Fig:3 Cloud Sandbox and appliance sandbox

Perhaps the most important advantage of cloud sandboxing is that it can be covered remotely in comparison to appliance-based sandboxing. When a user leaves the network, they might be exposed to threats because company appliances cannot accompany them. Whatever the location, the cloud sandbox can protect the entire network. Different Internet and web connections from guest networks are consistently used by remote employees that can be hijacked and/or used for cybercrimes due to the robust amount of people using combined with lack of protection.

Firms with a broad network and a large number of remote staff would probably benefit more from cloud sandboxing since it keeps remote workers protected. Cloud-based sandboxing can scale with a company, while appliances need to be traded for larger capacities or additional items must be bought. Appliances is not capable of remotely sandboxing suspicious content; however, it might be ideal for a smaller firm with few terminal devices that cannot leave the office building.

Both the sandboxing software, cloud-based and appliance- based may enhance protection against zero-day threats, although cloud security is a better option for large networks or organizations with more remote workers.

## V. Sandbox Applications

Some of the important Sandbox applications include:

- Browser plug-in content has always been dependent on the use of a sandbox, like Microsoft Silverlight, and Adobe Flash to view the content loaded from browser plugins. However, it

was notoriously difficult to sustain this form of content. .While playing the Flash game on a web page was safer than downloading the game and running the game as a standard program, content publishers have mostly moved away from those plug-ins for publishing HTML5 content that contains sandbox features to enable your browser to deactivate any features that may cause security risks.

- PDFs and other documents may include executable code, so Adobe Reader runs PDF files in a sandbox, which stops them from escaping the PDF viewer and interfering with the rest of the computer. Microsoft Office also has a sandbox mode that prevents system being tampered with unsafe macro structures.
- Mobile apps [11] are typically executed in sandboxes by mobile platforms. Applications on IOS, Android and Windows are prohibited in doing a variety of things standard desktop apps have permission for. For instance, mobile apps have to declare permissions for user's location access. The sandbox isolates applications and prevents the applications from tampering each o Web browsers: You can run a trustworthy web browser within a sandbox. If a web site exploits vulnerability in the browser, then the damage is limited to the sandbox and reduced.
- Software protection: Certain tools are available that users can make use of to run software that are not trustworthy in sandboxes, so they cannot access their private data or damage their devices. The software generally cannot detect that it is limited to a virtual environment, because the sandbox seems to be a complete system for the software.
- Security research: Security information professionals are using sandboxes to detect malicious code or for research purpose. For example, a security tool could visit sites to check files or install and run the software.

## VI. Sandboxing Benefits

Sandboxing solutions enables companies to set up, test, and launch software with the help of virtual environments it provides. This cutting-edge solution has become increasingly popular because they are accessible, flexible and can save a company a significant amount.

Virtual sandbox [5] environments have several applications. It is widely used to streamline and optimize the development process, identifying bugs and fixing it, testing patches. It can also double up as a working directory depending on objective the company.

- Sandboxing technology make use of virtual servers for testing software in an isolated environment. It enables Developers test certain features without having to worry about compatibility problems caused by other background programs.
- Repeated usage nature of sandboxing environments is the perfect way to test IT solutions. It equips a company to analyze malicious code, untrusted software and other risks Without contaminating its own systems.
- Sandboxes can also enable an external developer's mirrored production environment to develop an app using a sandbox web service. Sandbox solutions makes creating and deploying environments effortless even bigger at scale. It enables the users to test certain versions, incorporate new code lines and test them viz-a-viz control. This allows third-party developers to validate their codes ahead of taking it to the production environment.

- A Sandbox Application Programming Interface enables development and testing of APIs. It imitates the features of the production environment so as to produce simulated responses for APIs representing the behavior of a real-time device.
- Sandbox can be used to test software changes before they are launched, implying that there are lesser problems during and after testing because the testing environment is completely isolated from the actual production environment.
- Sandboxing can also be used to exploit unreported vulnerabilities for quarantining zero-day risks [12]. Although sandboxing cannot prevent zero-day threats, it provides an extra layer of security in isolating the threats from the rest of the network. When viruses and threats are quarantined, security researchers can use them analysis purpose and identify network vulnerabilities and patterns and help prevent attacks in the future.
- Sandboxing also complements other security systems, including behavior management and virus systems. It provides additional protection from some malwares that cannot be easily detected by an antivirus software.
- Cooperation is an important aspect of every company. The sandboxes are great to receive valuable feedback from different departments in the company because everyone with the right permissions can have access to them and can strengthen collaboration through all agencies
- Provides advanced networking connectivity and support for nested virtualization. You gain access to complex topologies and advanced networking features without rearchitecting when you work with a reputable provider of sandbox technologies.
- Integration of multiple builds of a project isn't easy. Sandbox technology enable the checking of compatibility of different builds and validation of the overall solution being developed properly
- Sales demos and virtual Proof of concepts usually include videos and different forms of multimedia presentations. Sandboxing enable the organization to engage potential customers and existing customers more interactively. Sandbox can enable testing a company's software from anywhere in the world on the terms of the company.
- Sandboxing also provides a Quality assured performance. Testing and performance optimization is a never-ending process in the field of software development. Sandbox can be used to test, optimize and enable the Quality Assurance teams to identify potential problems before they go unaddressed.
- Provide significant cost savings for your company. It's an expensive process to purchase, maintain and manage your own development laboratories. You will only pay for services that you use with cloud-based sandboxing.

## VII. Sandbox Evasion Techniques

Malware developers are working effectively in circumventing the new and most sophisticated methods for threat detection [14]. Some basic techniques for evading sandbox include the following

- Sandbox detection: Sandbox environments appears different slightly than a real environment of end user. Malwares either stall execution of harmful activities or terminate immediately

if it detects a sandbox.

- Exploitation of Weaknesses and gaps in sandbox: As sophisticated as sandbox, Malware developers can also identify and exploit the weak points. One example is that the sandbox cannot process obscure file formats or large file sizes or the sandbox incurs a blind spot where malicious code can be deployed if the monitoring system of the sandbox is circumvented.
- Incorporating Context-Aware Triggers: Context- aware malware works by exploiting weaknesses of the automated sandbox technology. For example, logical bombs could postpone code detonation for a period of time or until a trigger occurs, such as system reboots or mouse and keyboard interactions, typically occurs only on the end-user system.

## VIII. Limitations

Though sandboxing provides users with additional safety, it can also restrict the application capabilities. For instance, A sandboxed application may not allow command line input because commands are executed at the system level, hence utilities like backup programs and keyboard shortcut managers may not operate correctly. Henceforth it is difficult to sandbox certain programs.

## IX. Conclusion

Complex systems are always vulnerable, and the complexity of software only increases over time. How much ever secure coding practices and bug-resistant practices are adopted, attackers just have to pass through the defenses only once to succeed their effort of cracking sandbox. An Un-sandboxed application has the full access permission of the resources and the user system running the app. If that app or any framework it is linked against

contain security holes, an attacker can potentially exploit those holes to take control of that app, and in doing so, the attacker gains the ability to do anything that the user can do. Although Sandboxed app can’t prevent all attacks against the app, it minimizes the damage that can be brought about.

Sandboxes are more than an early testing tool for development. They serve as versatile tools from which every company can benefit if deployed in every phase of its development, ongoing testing at the project level, quality assurance and support.

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# Save the Power Consumption in Library for Readers with Automatic Power System using IoT

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***Abstract***

This paper discusses about the saving a power and automatic switching of library lighting system for library users. In this paper proposed a circuit that will control the main switch, which will be turned on only if a library user who would like to use library and person detected in library. The proposed circuit is based on PIR Sensor and Arduino Uno board. The human detection circuit can also be used to count the number of persons present in the library. The basic idea behind this paper is to reduce the librarian efforts to switch off and switch on the lights according to availability inside library. It also saves the amount power wasted when the library lighting system is on even in the absence of human being.

***Keywords:*** Library Management System (LMS), IoT (Internet of Things), PIR Sensor and Arduino Uno.

## I. Introduction

In recent years the people are looking only for automation system for day to day life. Even now the people are eager to save energy consumed in day to day life library users are becoming lazy to switch off the lights while leaving the library. So, the large amount of energy is wasted if the light is ON in the absence of human being inside a library. Generally, in Schools/ Colleges most of the students are not interested to switch OFF the consumer electronic appliances like fan, light etc., if they are not present. As more and more consumer electronic light and fans are used, the size of them is becoming large; more power consumption due to AC. lights and fans used in library area. Moreover, useless power consumption occurs in the absence of human being in public and private sectors. Using the automation in switching the lighting system large energy will be saved which will in turn save the money of the owner of the house. Now the people are looking forward for automation in all simple tasks they need to do. The people are trying to reduce human efforts. The automatic switching of home lighting system actually reduces the human efforts. By the use of automatic switching the person will not have given attention towards turning OFF the lights while leaving the room, this system also helps to reduce the power wasted when the lights, fans and other electric appliance are ON in the absence of any person. The components used are PIR sensor for detection of human being. In Today's life, electricity becomes a prior need to people as to enjoy their social activities thus they need enough electricity to carry out their activities. Lighting is very Significant to people as it is important to us in day or night. Due to increase of electrical energy production price, it is becoming more significant in conserving and saving in electrical energy consumption. Household is the place where a number of occupants live in together. There is a variety of household appliances used by them such as air-conditioner, personal computer, refrigerator and

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light system. Lighting system is one of the huge usages in the household where it has been placed in every section of places especially in every room. There are many different types of lighting technologies that are been used for the household such as fluorescent light and LED light. The LED lighting can minimize the usage of light because it only utilized 50% from the energy consumption in the household compared to fluorescent lighting.

Through the idea of designing an automatic room light, it is hoped that the product will be a great way for people to save their energy consumption. The designing of the automatic room light comes with the application where the light could be turned on or off according to the occupancy in the room. Another purpose for this project is to control and reduce energy consumption especially for home utilization. The occupant of a household usually consists of a variety range of ages such as children, teenagers and adults. There are many cases where these people come out from the room and they forgot to turn off the light unintentionally, these cases can lead to the cause of electricity wastages at home. Thus, by having this product, it is aimed to reduce the electricity utilization as well as to save the household spending.

## II. Literature Review

Vibhuti et al [1] proposed a system which operates with control of relays and with the use of WAGO PLC (Programmable Logic Controller) and Arduino Uno. Switching operation of devices such as tube light, fan, AC, etc. can be operated spontaneously by using PIR sensor and on the basis of environmental conditions. In real-time implementation, automatic control is done by sensor data and manual control is done by android application. But, difficulty in this paper is the controlling and monitoring of devices done by WAGO PLC and Arduino Uno both. These operations can be done by using only Arduino Uno.

Maslekar et al [2] proposed a smart lighting system in which Raspberry Pi has used. Raspberry Pi is monitoring lights and fans simultaneously. In the absence of person room lights and fans will automatically turns OFF. Energy is preserved by using this smart lighting system. The experimental results of this system have shown that 50% energy is conserved. But the difficulty is Raspberry Pi is more expensive than Arduino Uno.

Automatic Lighting and Control System for Classroom in which electrical light is controlled by Bluetooth, PIR sensor and relay. To switch ON or OFF the light Bluetooth module is connected to Arduino Uno which sends voice command from Arduino Uno by using the mobile android application. The experimental results have shown the 50% energy is conserved. But this paper can be implemented by removing the Bluetooth module as well [3].

In [4], the disquisitions speak about automatic room light system by using visitor counters operation. Depending upon the human presence, the room lights ON or OFF. There is no need of manual operation for switching. The PIR sensor is used to the human presence which is at the entrance of room. As visitor counter is used, there is increment in the counter when person enters in the room and this leads to turn ON the room light which is controlled by microcontroller program. If person exits the room, the counter decremented and this leads to turn OFF the lights. When all persons left the room then only lights in the room switched OFF. The difficulty in this system is that the door of room should not allow more than one person at a time.

## III. Methodology

Here we have given detail flow and methodology for our system.

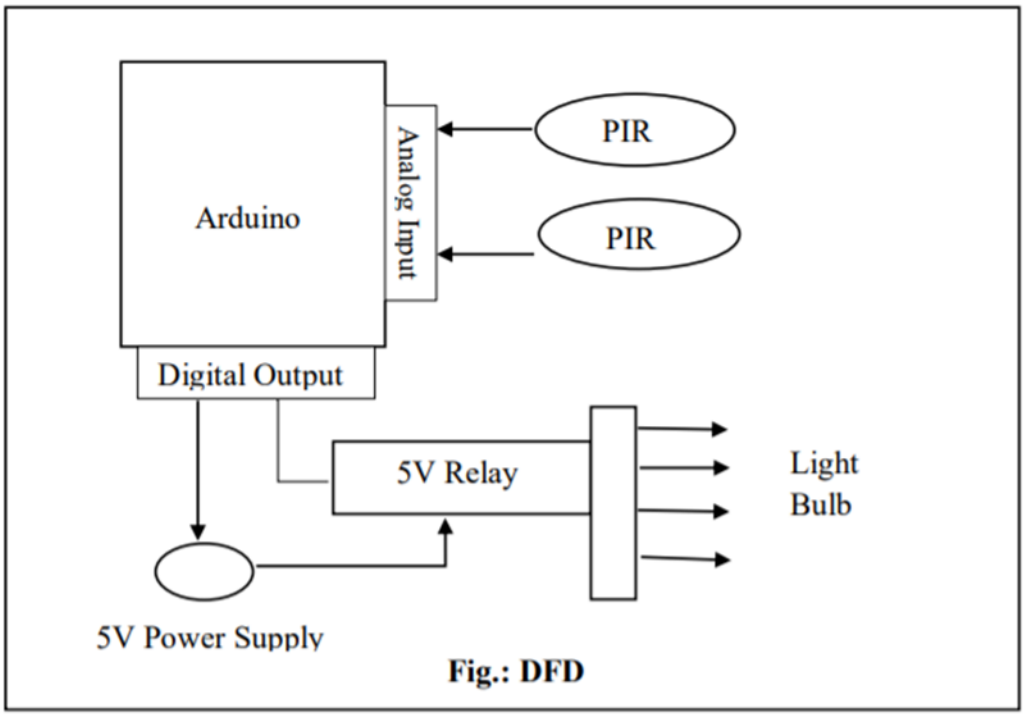


Fig1. Architecture and flow of automated system

For the experimetal study of the proposed model various internet of things components have been used. The breif details about the components is demonstrated in this section.

- Arduino UNO : A microcontroller is the brain of the Arduino Uno board which is ATmega328 ic. It consists of six analog inputs and also 14 digital input/output which 6 of them are PWM outputs. It uses simple C programming in Arduino software which can be uploaded from a computer into the Arduino through USB port. The operating voltage is 5V and can be powered up using USB or external battery supply.
- PIR Sensor : PIR sensors allow you to sense motion, almost always used to detect whether a human has moved in or out of the sensors range. They are small, inexpensive, low-power, easy to use and don't wear out. For that reason they are commonly found in appliances and gadgets used in homes or businesses. They are often referred to as PIR, "Passive Infrared", "Pyroelectric", or "IR motion" sensors. Analog Input Digital Output Arduino Light Bulb PIR PIR 5V Relay 5V Power Supply Fig.: DFD
- 5V Relay Module (Relay Board) : Relay is an electromechanical switch. It is hidden in all types of electronic device which consists of four important components which are electromagnet, armature, spring and set of electrical contacts. Relay usually being used in a

low power electrical circuit. Electronic device which can control the switch usually have a relay. The relay above is the combination of two separate independent circuits. The switch will control the power flow to the electromagnet. Electromagnet will turn on when the switch is turned on. The armature which is the second switch will complete the circuit when the electromagnet is on and turned the bulb on. The bulb will turn off when the electromagnet is off because the circuit will not complete when the armature is not attached.

- 100Ω Resistor : Resistor is being used in order to decrease the flow of the electric current. In this project, a 1 kΩ resistor will be used.
- LED : LED specifications provide vital technical information allowing you to mount and power your LEDs to maximize output and to maximize efficiency resulting in a prolonged life.
- Arduino Integrated Development Environment (IDE) : Java platform is used to make an IDE application which is the workspace debug and upload the coding from the software into the board.
- Arduino Language : The Arduino uses C or C++ language and based on Wiring. Arduino IDE consists of the Wiring library to make the input or output operation user-friendly. This program could be run using 2 functions which are setup() and loop().
- Breadboard: A breadboard or protoboard is usually a construction base for prototyping of electronics. The term "breadboard" is commonly used to refer to a solderless breadboard (plugboard) for it does not require soldering, thus make it reusable. This makes it easy to use for creating temporary prototypes and experimenting with circuit design without too much cost. The concept of "breadboarding" as prototyping is not confined to electronic design but in various field of expertise most especially in the field of engineering.
- Connecting Wires : A wire is a single, usually cylindrical, flexible strand or rod of metal which are used to bear mechanical loads or electricity and telecommunications signals. The term wire is also used more loosely to refer to a bundle of such strands, as in 'multi-stranded wire', which is more correctly termed a wire rope in mechanics, or a cable in electricity. Stranded wire is composed of a number of small gauge wire bundled or wrapped together to form a larger conductor, more flexible than solid wire of the same total crosssectional area and is used when higher resistance to metal fatigue is required. Stranded wire tends to be a better conductor than solid wire because the individual wires collectively comprise a greater surface area.
- Power Supply : An electric battery is a device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy. Each cell contains a positive terminal, or cathode, and a negative terminal, or anode. Electrolytes allow ions to move between the electrodes and terminals, which allows current to flow out of the battery to perform work.

## IV. Working Model Analysis

Arduino UNO is a microcontroller which provides open source platform to perform software and hardware operations. This is an advantageous project as Arduino Uno and PIR Sensor is used thereby lights in the room will turn ON automatically by detecting a human motion and stay turned

ON as long as the person remain present in the room. Initially we tested or methodology on Tinkercard. At the beginning, when no human is present in the room, the PIR Sensor's OUT pin is in the LOW mode. Hence, light of the room is OFF as shown in Figure 2

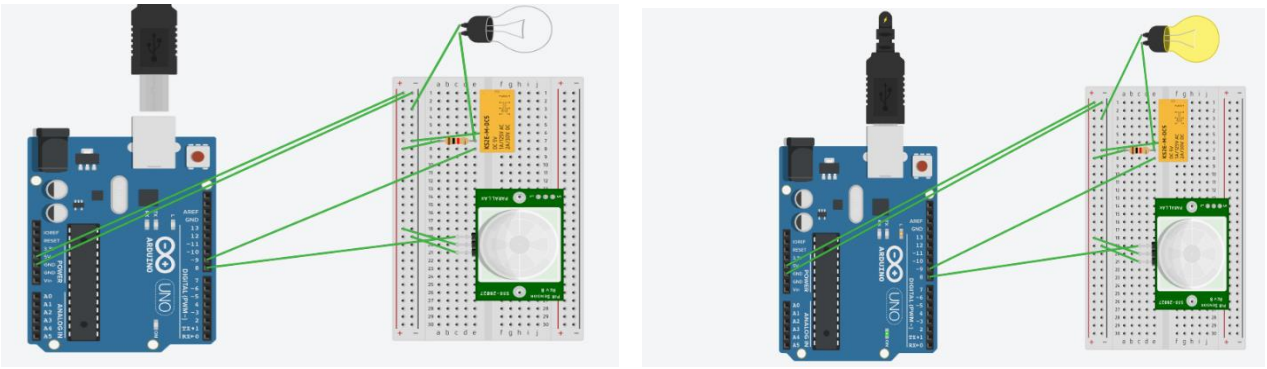

Fig 2(a). Initialize the component of Arduino UNO. (b). Person detected to the system

The output of the PIR Sensor goes HIGH as the person enters the room. PIR Sensor detects the Infrared (IR) radiation in the room. The Digital pin 8 of Arduino Uno is used to connect the Data OUT pin of PIR Sensor. When this becomes HIGH, the activation of relay takes place by Arduino Uno. So that relay pin is in the LOW mode; because relay is an active LOW device. Now, the lights will turn ON. This light maintains its state as ON as far as there is motion in the room as shown in Figure 2(b). The flow diagram of the model proposed is demonstrated in fig.3

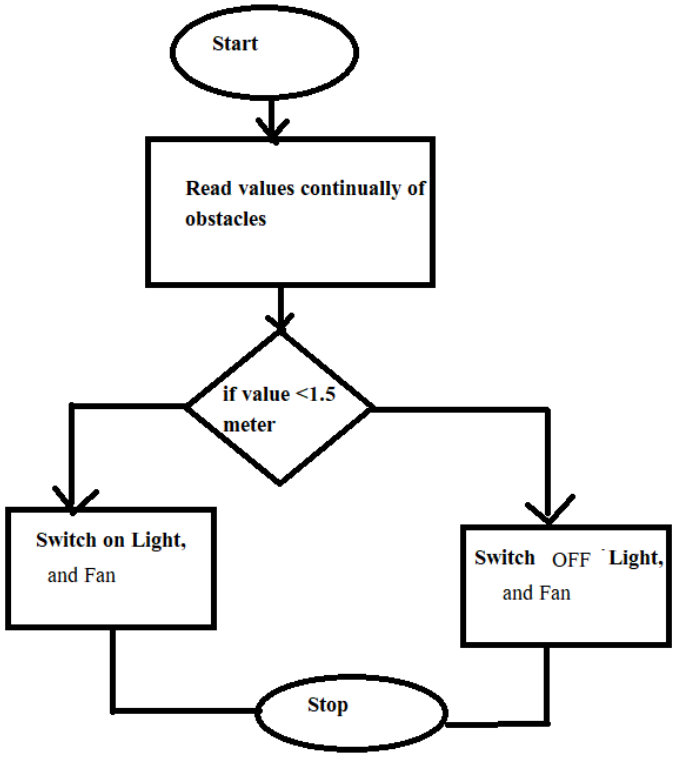


Fig 3: Flow diagram for the proposed model

Following Table1 displays status of FAN and Light ON or OFF

Table 1: Status of toggle of light sources based on person distance

| No. | Distance of person | Status of light fan |
|---|---|---|
| 1 | Person distance < = 1.15 meter | ON |
| 2 | Person distance > 1.15 meter | OFF |
| | | |

## V. Result Discussions

Following are the electric meter results observed before implementation of system and after implementation of automated system in private library. Table 2 displays the result before implementation of automated system.

Table 2: Sub-Meter reading of private library before implementing automated system

| No. | Month and year | Submeter reading |
|---|---|---|
| 1 | Jan 2019 | 67 |
| 2 | Feb 2019 | 70 |
| 3 | March 2019 | 77 |

The Table 3 displays the result after implementing the poposed automated model in our private library of the institute.

Table 3: Sub-Meter reading of private library after implementing automated system

| No. | Month and year | Submeter reading |
|---|---|---|
| 1 | Jan 2020 | 40 |
| 2 | Feb 2020 | 55 |
| 3 | March 2020 | 59 |

Following fig shows comparative results with or without automated system It has been observed while studying the poweer consuption across the using this library systm almost 30% electricity saved is suppoed to be saved. The comparative analysis for the month of Jan,Feb and March 2019, of power consumptions is visible in fig. 5.

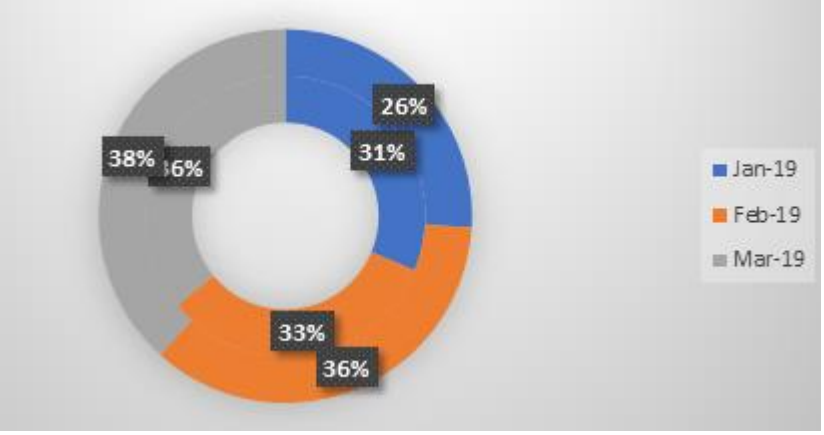


Fig. 5: Comparative results

## VI. Conclusion

Internet of things as we studied has put forth many innovative solutions to our society ranging from home appliences to medical equipment to education gadgets. There are applications in pluace which are working for the benefit of humans leading access as well as economical benefits. In this paper we have studied the power consumption in many places where movement of masses is periodical and diverse across the vicinity. We have proposed a power saving model for monitoring the moviement based on which the context toggeling of light sources can be controlled. For the experimental analysis of our model we have tested it in a private library of our institute. It has been observed, use of this model definitley control and save the power consumed smartly. The automated model for library implemented at Bid knowledge library. The results shows almost 30% electricity saved due to automated system. Further enhancement may include the data analysis of the collected data using sensors, which is being stored on the cloud for making the model intelligent enough to recommend the locations as well.

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# Sustainable Design of a Multipurpose Integrated Sports Complex Using Steel Composite Structure

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***Abstract***

Building an economical multipurpose integrated sports complex using steel composite structure for the college campus. The structure is designed to satisfy various sport events activities and for better sports management in a very limited area. It is like developing a sustainable sports complex structure in a very optimum way without interfering the environmental features. The main challenge with the design of structure is the bearing capacity of soil of the existing structure is not adequate, hence a composite light weight sustainable structure is used. The integrated design of composite steel structure planning can be the most interesting subject for an engineer. It is one of the rare moments that one can cherish for lifetime. The task of structure planning and designing will involve several aspects of modern construction practices. The sports complex serves for badminton, kabaddi, chess, carom, table tennis, kho-kho, football etc.In this project, to design a multi-purpose court of height 25' (7.6m) over a existing RCC building of height 24'(7.3m) thus the total height of structure will be 50'(14.9m) by using structural design software, STAAD Pro 2007. Design of this building follows the Indian standards IS: 800:2007, IS: 806:1968, IS: 808:1989, steel table. Several dead load, live load and wind load are imposed on columns, beams, purlins and truss members that are made of universal beam and angle section. The design is checked for its maximum capacity to guarantee its safety. To choose suitable sections, one needs to design ether manually or by using software so that it proves to be an effective design for the building.

***Keywords:*** *multipurpose, integrated, sustainability, sports complex, etc.*

## I. Introduction

Structural engineering is a sub-discipline of civil engineering in which structural engineer are trained to design and form the structures. In civil engineering, structures are basically categorize into R.C.C and Steel structures. RCC is a composite material. concrete has relatively low tensile strength and ductility which is counteracted by reinforcement having higher tensile strength as well as ductility. Another type of structure is steel structure which is mostly constructed with the mild steel. It has high strength per unit mass and also maintains the aesthetic view. Structural steel has many applications in the construction industry.

Structural steel has a high strength to weight ratio which encourages its applicability in construction ofbuildings, warehouses, bridges, factories etc. Beams, steel frames, columns, bars, girders, plates and many others are created by structural steel fabricators which are used in the construction industry most of the steel structure are made up of mild steel which comes in the market with

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variable content of carbon.In this research work, the integrity, and sustainability and using the complex for multipurpose sports activities in a limited area is a big challenge to the planning & design principles. Hence all latest material innovations are reviewed to provide an alternative solution.

## II. Problem Formulation

In the given project various ideas regarding the green buildings are used for creating a sustainable design of the integrated sports complex. Construction of Green building in college campus will decrease the resource usage in construction process and future use of the building. The goal is to reduce CO2 emissions, energy use, and water use to create healthy atmosphere for students. The goal is to reduce CO2 emissions, energy use, and water use to create healthy atmosphere for students. Design-related decisions are taken on daily basis, impacting "sustainable development". Sustainability and design are interconnected. The term "design" refers to practices applied to the making of products, services, and business and innovation strategy. Sustainability is the property of continuance (refer fig 1).

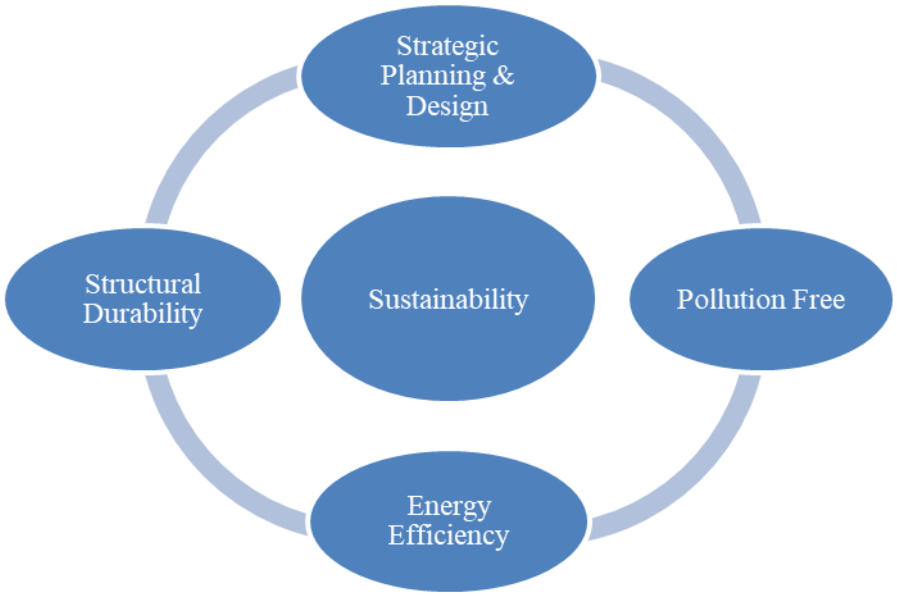


Fig. 1. Sustainablity and its components

### Objectives of the Study

The specific objectives of this study are;

- To apply civil engineering concepts in a multipurpose integrated sports complex project.
- To design a sports complex according to smart and green building criteria.
- To learn application of various IS codes and building bye-laws used in design and planning.
- To use modern technology effectively and economically during construction (3R).
- To perform standard testing.
- To use different software for planning, designing and scheduling.
- To eliminate negative environmental impact on structure through skillful, sensitive design.

## Background

Composite elements include two or more different materials. The Advantage of composite elements is that the properties of each material are combined to form a single unit that can perform better than the individuals. The most popular form of composite element in construction is steel-concrete composite, Other types of composites include; steel-timber, timber-concrete, plastic-concrete.

## III. Literature Review

Construction worker fatalities related to trusses analysis included study of the type of truss, the truss material, the activity taking place at the time of the accident, the release of the hoisting equipment, the initiation of the accident, the presence of bracing materials, the type of construction, the length of the trusses, the location of the incident, the type of accident (fall, caught-in/between, struck by, or electrocution), and the year the fatality occurred. Many of the accidentsoccurred at elevation and were initiated in large part by moving or falling objects. The study recommends that further research should focus on the stabilization of incomplete roof structures and the implementation of best practices for fall protection while performing truss-related work.

Y. Xiao et al. in his research work studied a new form of laminated bamboo or Glubam at the Hunan University. The experimental studies on model Glubam trusses are discussed in his paper.Shin-ho chao et.al in their research on the special truss moment frame which is a relatively new type of steel framing system suitable for high seismic areas found that the frames dissipate earthquake energy through ductile special segments located near the mid-span of truss girders. They stated that STMFs generally have higher structural redundancy as compared to other systems because four plastic hinges can form in the chords of one truss girder. The redundancy can be further increased if web members are used in the special segments. Also the open webs can easily accommodate mechanical and electrical ductwork.

Sourabh Bhargava et.al worked on advanced techniques of low cost earthquake resistant design and construction that can be in corporate in constructing earthquake resistant buildings which can reduce cost and make it safer to live. Waste Tire Pads- This technique focuses on the experimental studies conducted on the development of low-cost seismic base isolation pads using scrap automobile tyre. study aims at cost and weight reduction of seismic base isolation pads by recycling otherwise useless material scrap tyre.

Durgesh C. Rai adopted the basic basic design criterion, which any earthquakeresistant structure must satisfy seismic demand and computed capacity. He worked on complete probabilistic analysis and design approach will gradually replace deterministic approaches, especially in the characterization of the loading environment. His research predicts the conventional descriptive codes to go obsolete. The development of new structural systems and devices will continue for baseisolation, passive energy dissipation and active control systems, along with the proliferation of non-traditional civil engineering materials and techniques. The area of soil–structure interaction perhaps the least understood aspect in the field of earthquake engineering is poised to witness the emergence of new numerical techniques to model nonlinear soils and structures in a manner that was not possible until now, due to the enormous computational efforts required.

Outinen et.al worked on automatic water supression with effective sprinkler systems that ensure the fire protection of steel structures without passive fire protection. In his research a steel framed hall was constructed, the sprinkler system was installed to the ceiling and the studied steel trusses, beams and columns and other parts of the building were equipped with temperature detectors. The system

was tested against standard ISO-fire. The fire load was produced by heptan-spray burner, which was situated centrally under the studied structures spreading the fire with three nozzles. The temperatures were measured from tubular steel trusses, beams and columns. Also the temperatures from the connections, bracing and steel sheeting were measured. The height of the steel truss was about 1.5m and it was built from different sized cross-sections.

Rainer Kolischet.al presented a set of benchmark instances for the evaluation of solution procedures for single and multi-mode resource-constrained project scheduling problems. The instances have been systematically generated by the standard project generator ProGen. They are characterized by the input-parameters of ProGen. The entire benchmark set including its detailed characterization and the best solutions known so-far are available on a public ftp-site. Hence, researchers can download the benchmark sets they need for the evaluation of their algorithms. Additionally, they can make available new results. Depending on the progress made in the field, the instance library will be continuously enlarged and new results will be made accessible. This should be a valuable and driving source for further improvements in the area of project type scheduling.

Amit Kumar et. al (2013) on their experimental investigations concerning the compressive strength of concrete made the following observations. The compressive strength of M20 grade Concrete increases when the replacement of cement with ceramic powder up to 30% replaces by weight of cement and further replacement of cement with ceramic powder decreases the compressive strength. Concrete on 30% replacement of Cement with Ceramic Powder, Compressive Strength obtained is 22.98 N/mm2 and vice-versa the cost of the cement is reduced up to 12.67% in M20 grade and hence it becomes more economical without compromising concrete strength than the standard concrete. Utilization of Ceramic waste and its application are used for the development of the construction industry, Material sciences. It is the possible alternative solution of safe disposal of Ceramic waste.

Parekh et. al (2011) compares all aggregate propertiesand their effects on concreting work. Similarly the properties of recycled aggregate concrete were also determined and explained. Basic concrete properties like compressive strength, flexural strength, workability etc are explained here for different combinations of recycled aggregate with natural aggregate. In general, present status of recycled aggregate in India with their future need and its successful utilization were discussed. This leads to an idea that strength and economical like factors simultaneously shall be the part of future study.

## IV. Methodology

Design changes and rework are inevitable in construction projects. The objectives are to analyze the relationship of design changes and the consequent rework, to recognize their resulting impacts on project performance and to provide insights for incorporating sustainability and integrity aspects.The various case studies along with findings indicate that planning & design incorporating sustainability are key characteristics. (Refer Fig 2 and 3 for structure and design)

*Sustainability & Quality Management in the Design and Construction Phase*

Construction industry plays an important role in the development of any country. The development of construction industry depends on the quality of construction products and projects. Improvement in the quality of construction projects is linked with quality management in the project life cycle. Although quality management at every stage of project life cycle is important but the quality management at the design and construction stage contributes significantly on final quality outcome

of construction projects. This paper therefore highlights the importance of quality management in the design and construction phase. The quality management will add on durability to the structure

*Construction Performance Control in Steel Structures Projects*

Steel structural projects are relatively special field of construction projects. The steel structure projects differ from conventional structural engineering projects mainly in the special problems that have to be considered during construction, transportation, installation and operation. Steel structural projects are a relatively special field of construction projects. There are many factors that impact on productivity in this field. The construction industry especially the construction of steel structure projects is rated as one of the key industries. It helps in developing and achieving the goal of society. Use of steel compact structures in a very limited space allows the integrity to the structure.

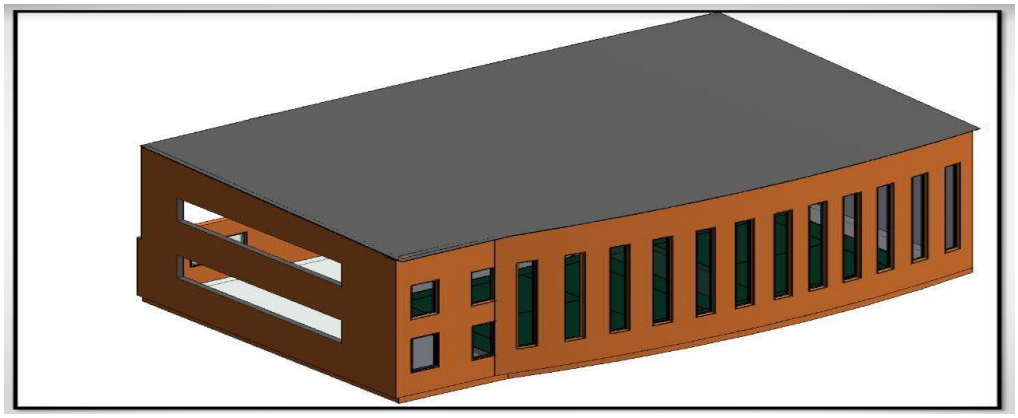

Fig. 2. Architecture of Structure

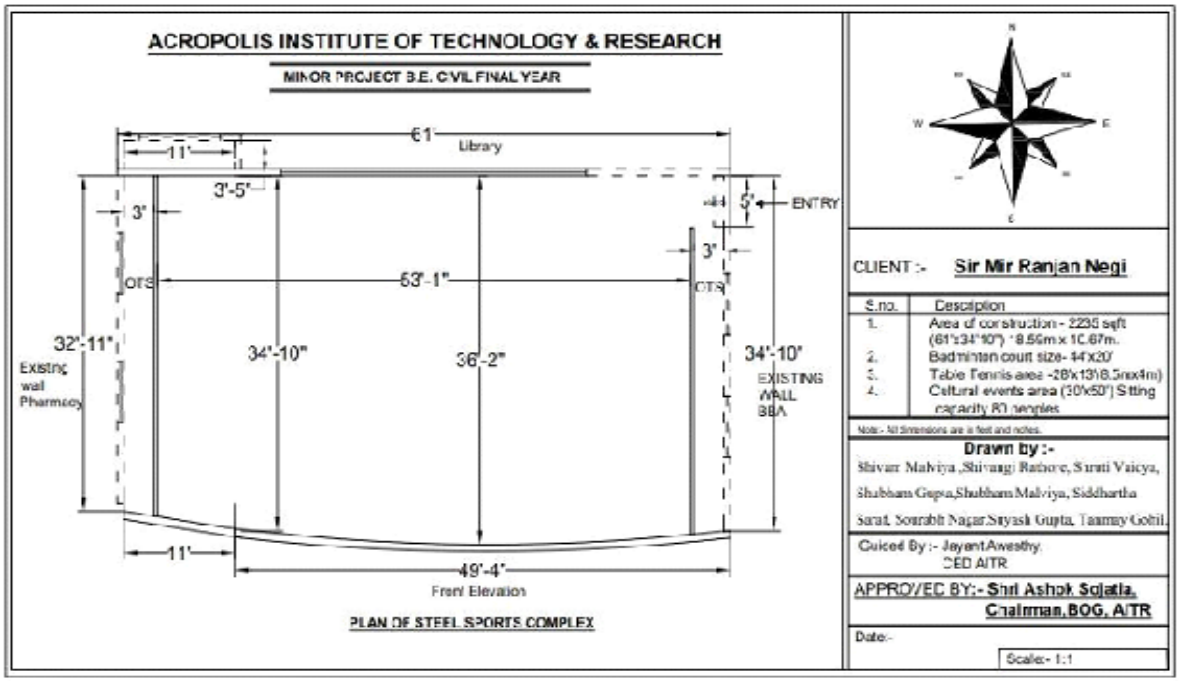


Fig. 3. Architectural Design

## V. Result and iscussions

1. The integrity of the elevation of existing building is matched with the multipurpose steel framed composite structure.
2. Speedy construction work was done; time limit proposed was 28 days to complete the work.
3. Various research papers on composite structures were studied to incorporate use of latest materials.
4. As per the studies various suitable and economical sections & materials were selected.
5. Structure design is done manually following the guidelines of applicable Indian standard codes.
6. Pre existing soil report was analyzed to assess about the integrity of the structure.
7. Light weighted flooring material used to level the floor area and to maintain sustainability.
8. Puff fiber sheet is proposed to be used for the walls and roofing material due to its suitability and durability.
9. Awning windows are used to reduce weight of the structure.

## VI. Conclusion

1. Sustainable design of the multipurpose integrated sports complex using steel composite structure is achieved.
2. Impact of the construction on the environment is minimized use of the smart construction material techniques.
3. Construction was carried without intruding the existing structure and by using light weight steel sections and latest puff materials which gives integrity to the structure.
4. Codal references considering durability aspects allow designing variable sections proves to be the best approach.
5. Floors are of asphaltic removable materials so that multipurpose concepts will be applied.

Acknowledgements

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# Design of Porous Pavement

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***Abstract***

Porous asphalt pavements offer an alternative technology for storm water management. A porous asphalt pavement differs from traditional asphalt pavement designs in that the structure permits fluids to pass freely through it, reducing or controlling the amount of run-off from the surrounding area. By allowing precipitation and run-off to flow through the structure, this pavement type functions as an additional storm water management technique. The overall benefits of porous asphalt pavements may include both environmental and safety benefits including improved storm water management, improved skid resistance, reduction of spray to drivers and pedestrians, as well as a potential for noise reduction. Special consideration is required in order to obtain higher air void percentages while maintaining strength and durability within a cold climate. The objectives of this study were to evaluate several laboratory porous asphalt mix designs for durability and strength in cold climate conditions. The porous asphalt mixes consisted of a porous asphalt super pave mix design method whereby the asphalt binder type was varied. Based on the preliminary laboratory results, an optimal porous asphalt mix was recommended.

***Keywords*:** Porous asphalt pavements, asphalt mix designs, storm water management.

## I. Introduction

The concept is simple: Construct storm water detention basins under the street and parking structures. These basins are designed to collect storm water from structures, pavements and other areas of a development and hold the water until it can percolate into the soil. The porous asphalt pavement is then placed over the top of these basins.

These pavements are designed to let the water flow through them and into the detention basin. The performance of porous asphalt pavements is similar to that of other asphalt pavements. And, like other asphalt pavements, they can be designed for many situations. Common applications of Porous Asphalt Pavements are parking lots, side-walks, pathways, shoulders, drains, noise barriers, friction course for highway pavements, permeable sub base under the conventional flexible or rigid pavements and low volume roads. In addition, porous asphalt can also be used as an application for tennis courts, patios, slope stabilization, swimming pool decks, green house floors, zoo areas etc.

The Economic Benefits includes: reduction in storm water runoff, including reduction of temperature, total water volume, and flow rate, increase in groundwater infiltration and recharge, provides local flood control, improves the quality of local surface waterways, reduces soil erosion, reduces the need for traditional storm water infrastructure, which may reduce the overall project cost, increases traction when wet, reduces splash-up in trafficked areas. Based on the preliminary

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laboratory results, an optimal porous asphalt mix was recommended on the basis of various laboratory test of asphalt mix design.


Fig. 1 Schematic layer of porous asphalt pavement & Thickness of Layer

## II. Literature Review

Chavanpatil et.al. (2002) analyzed porous asphalt pavements are an alternative technology that differs from traditional asphalt pavement designs in that the structure permits fluids to pass freely through it, reducing or controlling the amount of run-off from the surrounding area. By allowing precipitation and run-off to flow through the structure, this pavement type functions as an additional storm water management technique accounting for ground water recharge. The overall benefits of porous asphalt pavements may include both environmental and safety benefits including improved storm water management, improved skid resistance, reduction of spray to drivers and pedestrians, as well as a potential for noise reduction.

Kandhal and Mishra (2003) proposed Multi-storied commercial and residential buildings, which significantly increase the demand for water supply, are increasingly being constructed in urban India. In many states of India such as Bihar, Delhi, Gujarat, Haryana, Punjab, Rajasthan and Tamilnadu, the ground water is plunging at an alarming rate. Responsible town planners, architects and civil engineers must be proactive and integrate rainwater harvesting techniques in the design of all types of buildings, parking lots and low traffic roads/streets. This would recharge the ground water in over exploited/critical areas of India. The revolutionary technology presented in this paper addresses that very need.

Imran et al. (2007) described uncontrolled storm water runoff not only creates drainage problems and flash floods but also presents a considerable threat to water quality and the environment. The paper focuses on drainage systems and storm water runoff quality from roads, driveways, rooftops and parking lots. PPS are very effective for storm water management and water reuse. Moreover, geo textiles provide additional facilities to reduce the pollutants from infiltrate runoff into the ground, creating a suitable environment for the biodegradation process. Furthermore, recently, ground source heat pumps and PPS have been found to be an excellent combination for sustainable renewable energy. In addition, this study has identified several gaps in the present state of knowledge on PPS and indicates some research needs for future consideration.

Mullaney and Lucke (2013) studied an international literature review was undertaken to identify the most appropriate design for a pervious paving system. This literature review was to form the basis of a design for a new research study on the benefits of using pervious pavements to promote street tree health has recently commenced at the University of the Sunshine Coast in Australia. The review identified four typical pervious paving surfaces porous concrete porous asphalt, permeable

interlocking concrete pavers, and concrete and plastic grid pavers. All four pavement surfaces were found to have high storm water pollutant removal performance in a variety of conditions, with a wide range of designs. This paper summarizes the literature review findings and is intended as a practical resource for designers and researchers of pervious pavement system.

Parmar and Jain (2014) analyzed feasibility of Porous Pavement at Hatkeshwar area of Ahmadabad City, study represents the experimental work related to porous pavement feasibility. Porous pavements allow storm water runoff to filter through surface voids into an underlying stone reservoir where it is temporarily stored and/or infiltrated. The above road network has the history of the accumulation of water in the area during the monsoon season for long duration. To calculate the above objective the rainfall data for the area during the different day, month is collected. The volume data is the other important aspect for identifying the low volume road. The quality of soil sub grade is the other data, which is collected for determining the thickness of porous asphalt pavement. The soil quality is also useful in order to identify suitability of disposal of the seepage ground water nearby to the stream/artificial drainage link.

K. Arvind et. Al. (2007), Pavement design with central plant hot-mix recycled asphalt mixes, central plant hot mix recycling is one of the popular techniques adopted for recycling of asphalt pavement materials. Thus, there is a need for conducting performance-related tests before finalizing any recycled mix design. The present paper discusses laboratory study conducted on recycled mix design of two different Reclaimed Asphalt Pavement (RAP) samples, and subsequently develops an integrated mix-design-structural-design approach for hot recycled mix. The total cost of the asphalt layer construction is estimated considering the constituent proportion and the pavement design thickness so that the designer can choose the best option.

Dr B V Kiran Kumar et. Al (2014) Porous asphalt pavement, a tentative mix design guidelines- by new generation open graded friction course approach, Porous asphalt pavements are an alternative technology that differs from traditional asphalt pavement designs in that the structure permits fluids to pass freely through it, reducing or controlling the amount of run-off from the surrounding area. The objectives of study were to obtain a porous asphalt mix design procedure for the achieved gradation recommended by National Centre for Asphalt Technology using the locally available aggregates, to determine the optimum binder content by adopting New Generation Open-Graded Friction Course design concept, to evaluate the performance of the mix in the laboratory in terms of Permeability, Moisture Susceptibility and Marshall Stability, and thereby develop tentative mix design guidelines for Porous Asphalt which has adequate permeability and durability that suits Indian climatic conditions.

## III. Methodology

On the porous asphalt pavement some basic tests are to be performed on aggregates and bitumen. The flow chart has been given to explain the proposed methodology. The methodology includes different testing of Aggregate and Asphalt materials to obtain various characteristics suitable to porous pavement. The various tests performed are gradation of aggregate impact value, Los Angeles, Specific gravity and water absorption, shape and crushing value test etc. Similarly, for Bitumen Softening, Ductility, Specific Gravity flash & fire point. For Stability of Concrete Marshall test is done and for porosity of the concrete permeability test is performed. Finally, a comparative analysis has been done to an optimal porous asphalt mix.

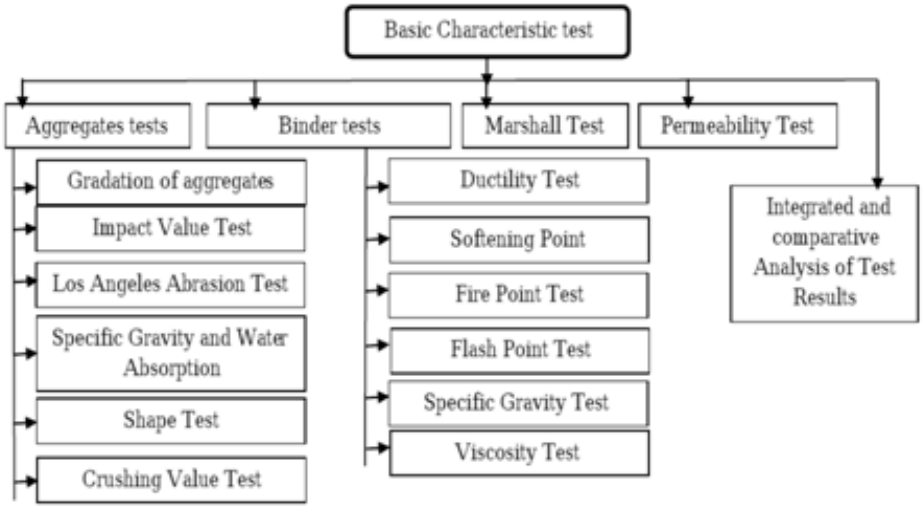


Fig 2. Basic characteristic test

## IV. Data Analysis

*Achieving the desired gradation*

The different sized aggregates were mixed together for obtaining the desired gradation defined by National Centre for Asphalt Technology (NCAT) by adopting the method of 'Proportioning of Materials by Roth fetch's Method and thus the proportions of various aggregate sizes were obtained.

*Optimum Binder Content*

The binder content of 6 % fulfils all the criteria recommended by NCAT for OGFCs (Open graded friction courses). Therefore, the bitumen content of 6 % is finalized as the optimum binder content for Porous Asphalt throughout the work and is adopted for performance evaluation of Porous Asphalt.

**Mix Design Guidelines**

*Selection of Aggregates and Binder*

The first step in the mix design procedure for 'Porous Asphalt Pavement' is the selection of the materials that are suitable for its design. It mainly includes the selection of aggregates and binder.

*Design Gradation*

Design gradation as per the % passing and sieve size according to mix design guidelines is tabulated below.

Table 4.1 Passing percentage as per sieve size

| Sieve Size, mm | Percentage Passing % |
|---|---|
| 19 | 100 |
| 12.5 | 85 – 100 |
| 9.5 | 55 – 75 |
| 4.75 | 10 – 25 |
| 2.36 | 5 – 10 |
| 0.075 | 2 – 4 |

## Performance Evaluation

*Permeability:* Cylindrical Porous Asphalt specimens are subjected for falling head permeability test. The co-efficient of permeability of 100 m/day is acceptable.

*Moisture Susceptibility:* Porous Asphalt Mix specimens are conditioned in water bath maintained at 60°C for 24 hours, followed by placing the same specimens in a water bath maintained at 25° C for 2 hours and then subjecting these specimens to Indirect Tensile Test; the results of which are compared with the unconditioned specimens. TSR value more than 80 percent is considered acceptably.

## Tests of Aggregate

The test results of gradation of aggregate as per National asphalt pavement association is given in Table 4.2 The various test has been done on the basis of IS code methods. The results have been recorded in the tabulated form.

Table 4.2 Gradation of Aggregate Test Results

| IS Sieve Size (mm) | Aggregate retained (gm) | % Agg. Weight retained | Cum % Agg. Total weight retained | % Agg passing | National asphalt pavement association |
|---|---|---|---|---|---|
| **20** | 0 | 0 | 0 | 100 | 100 |
| **12.5** | 180 | 15 | 15 | 85 | 85-100 |
| **10** | 360 | 30 | 45 | 55 | 55-75 |
| **4.75** | 540 | 45 | 90 | 10 | 10-25 |
| **2.36** | 60 | 5 | 95 | 5 | 5-10 |
| **0.075** | 36 | 3 | 98 | 2 | 2-4 |

**Permeability Test**

Permeability is one of the critical properties, as it indicates the ability of the porous asphalt to drain out the fluid. The falling head permeability's was conducted using permeability.

The Permeability test was conducted on nine cylindrical porous asphalt specimens, (101.6 mm dia., and 63.5 mm ht.) by varying the binder content i.e. 4%, 5%, 5.5%, 6.0%, 6.5% and 7%.

$$Q=KIA \qquad \ldots (4.1)$$

Where;
Q = Discharge in units of length cubed per unit time (L3/T)
K = Hydraulic conductivity in units of length per unit time (L/T)
i = Hydraulic gradient in units of length per length (L/L)
A = Cross sectional area in units of length squared (L2)

## V. Results & Discussion

The results of all the tests conducted on aggregate and Bitumen as asphalt mix has been tabulated below Table no 5.1 to 5.5. In the study results are in measuring units.

Table 5.1. Aggregates Test Result

| Name of Test | Result | Code Provision |
|---|---|---|
| Impact value Test(IS 2386- Part1) | 28% | <30% |
| Aggregate Crushing value Test (IS 2386 - Part IV) | 26% | <35 |
| Los Angel's abrasion Test (IS 2386 -Part V) | 34.6% | <35% |
| Specific gravity of aggregates (IS 2386-part-III) | 2.59 | 2.5-2.9 |
| Flakiness index % | 10.04 | <15% not exceed 25% |
| Elongation Index % | 10.95 | <25% |
| Water Absorption%(IS 2386) | 0.206 | 0.1-2.0% |

Table 5.2. Bitumin Test results (VG30)

| Name of Test | Result | Code Provision |
|---|---|---|
| Ductility Test (IS:1208-1978) | 87cm | >45 cm |
| Softening Point Test (IS:1205-1978) | 58°C | >47°C |
| Specific gravity Test (IS:1202-1978) | 1.075 | 0.97-1.02 |
| Flash and Fire Point Test (IS:1209-1978) | 360° C 375° C | >220° C |

**Bitumen Porosity Tests Results**

The following are the performance tests results carried out on the Porous Asphalt specimens. Three performance tests were conducted which included Permeability, Moisture Susceptibility and Marshall Stab.

Table 5.3. Permeability of porous asphalt specimen

| **Bitumen Content, %** | **5.50** | **6.00** | **6.50** |
|---|---|---|---|
| **Co-efficient of permeability cm/s** | 0.49 | 0.39 | 0.33 |

Table 5.4. Tensile Strength Ratio of Porous Asphalt Mix

| **No of blows** | **50** | **60** | **75** |
|---|---|---|---|
| **Tensile Strength Ratio, TSR %** | 69.93 | 77.61 | 81.14 |

Table 5.5. Marshall Stability and Flow of Porous Asphalt Mix

| **No. of Blows** | **Marshall Stability, Kg** | **Flow, mm** |
|---|---|---|
| **50** | 1213 | 4.60 |
| **60** | **1395.3** | **3.75** |
| **75** | **1607.2** | **2.36** |

## VI. Conclusion

Based on the observations made on various tests results, the following concluding remarks may be derived

1. The aggregate gradation consists of 100 percent of 19 mm down sized aggregates but requires less than 15% of the aggregate fraction passing 4.75 mm, so that the compacted mix becomes permeable and provide adequate permeability.
2. In order that the stone-on-stone contact condition is achieved in Porous Asphalt pavements, it demands the use of modified binders such as Polymer modified Bitumen or Crumb Rubber modified Bitumen.
3. For the Porous Asphalt to be permeable, air voids content of 18 percent and above is necessary.
4. The abrasion loss of the un-aged Porous Asphalt can be reduced significantly by increasing the percentage binder content or by using a modified binder such as the Crumb Rubber modified Bitumen due to improved flexibility
5. The tests on the drain down potential of Porous Asphalt specimens reveals that binder contents exceeding 6 percent shows more drain down loss of binder exceeding the permissible value of 0.3 percent.
6. Permeability test results at various binder contents reveal that an increase in binder content decreases the value of co-efficient of permeability.
7. Increase in compaction effort has also revealed the rise in the values of Stability of the Porous Asphalt specimens and fall in the flow values.

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