A REVIEW ON IMPROVISED EXPLOSIVE DEVICES AND THE HUMANITARIAN HARM CAUSED BY THEM

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ABSTRACT

Improvised explosive devices (IEDs) in all their forms have emerged as the most serious threat. These devices can range from simple explosive devices to complex military systems using high-grade explosives. A thorough grasp of the many types of devices and their effects is required for proper mass casualty event planning and management of the complex poly trauma victims that they usually bring. They may wreak havoc on a landscape. Depending on the desired target, they can be initiated in a variety of ways. As a result, there is a pressing need to research and ameliorate the mechanism of extremities harm induced by these devices. These improvised explosive devices are generally uncommonly encountered outside the battlefield.

The majorities of vulnerability evaluations presume that an improvised explosive device would attain maximal TNT equivalency and detonate effectively. They are still a popular terrorist weapon. These are unusual explosive weapons that can be used in a variety of ways to cause injury, fatalities, and destruction of property in both military and civilian conditions. IEDs continue to be a domestic menace.

The science and damage profile of these devices are described in this review. The humanitarian devastation inflicted by IEDs is thus depicted.

KEYWORDS: - improvised explosive devices, explosives, detonation, injury, impact testing, biomechanics, ground penetrating radar, detection, prevention, National Bomb Data Centre

INTRODUCTION

Explosive substance is any solid or liquid substance or addition of two which itself can cause chemical reaction and produce gas at very high temperature or pressure or high speed so as to cause damages in nearby proximity.

Pyrotechniques is an such substance explosive in nature or any mixture of substances designed to produce effects by heat, light, smoke, sound or gas or any combination of all as a result of non detonation or self sustainably reacting exothermically. Explosion is any rapid expansion of gases resulting from a physical or chemical action that produces a pressure .

There are generally four types of explosions which are:Mechanical Explosion, Chemical, Nuclear and Electrical explosion. Explosives can be classified based on velocity and on the basis of sensitivity. Based on velocity, we categorize explosives as low explosives which are also often termed as deflagerating explosives because in these explosives the speed of burning is less than the supersonic speed and surrounding speed. The other category of explosives based on velocity is high explosives or detonation explosives as the speed of urning of these explosives is greater than surrounding sound and supersonic speed. Based on sensitivity, explosives classified as primary which shock sensitive, basically used to detonate secondary explosives, the second being secondary explosives which are base explosives and generally not sensitive to heat, friction, and shock, secondarily explosives acting as the main charge, these are bombs placed at the scene of ongoing chaos or scene where intended damage to be produced, the third category of explosives is tertiary explosives which being so insensitive to heat, shock as well as friction that they can only be detonated by intermediate explosive secondary explosives.

An IED is simply a “homemade” bomb, used for any criminal or terror purpose or to disturb the peace of the area and create fear among locals, which is often done by insurgents. These explosive devices are available in various forms, being a small pipe to a much better device both capable of causing immense destruction to humans and property.

The term “IED” was very commonly used after the Iraq War. These devices are so unusual in their way that these can be deployed in various ways. Terrorists, criminals often prefer these explosive as the ingredients are easily available and the device can be very easily made. IEDs tend to cause much more humanitarian harm than land mines, the type of close contact injuries caused typicly these homemade explosives are much more lethal and fatal than land mines. Although the mechanism of injuries being similar in both landmines blast and IEDs, the considering and deciding factor associated with harm caused by both is based on the closeness of the victim to the explosive. Researches showed that in pattern 1 injuries which where the victim suffers the maximum effects the explosion is more fatal in those associated with IEDs.

In this review article, we will conduct a overview study on Improvised Explosive Device, their components, power source, types, collection, preservation and their evidentiary importance, and their effects to humanitarian society.

AIM OF STUDY

A dangerous homemade bomb, made from military or nonmilitary components, frequently engaged by insurgents, maoists, as most preferred weapon for destroying lives and property against a military or paramilitary might . When installed a road side explosives, IEDs can damage communication, signals of the area, halts communication , and create fear among locals. Even an entire structure can also be collapsed by IED. IED has been widely used to disrupt convoys of securioty personnel when they go from one place to another carrying ammunition or reinforcement. Large vehicle-aided IED can also create massive havoc at intended area. These explosives has been the weapon of choice for terrorists owing to their low cost, easy availability, high effective. According to a study conducted by National Bomb Data Centre (NBDC) in 2018, India had recorded the highest number of blasts in the world. Shockingly These numbers of India were far higher than Iraq and Pakistan. In the year 2016, there were 337 IED blasts in India whereas Iraq had 221 IED blasts, whereas in 2015, 268 IED blasts recorded in India and 17o IED blasts in Iraq. Back in 2015, 2016 it was concluded that states like Chhattisgarh, Jammu and kashmir, kerala, West Bengal, Manipur, Odisha and Tamil Nadu. Recently a 2019 study of NBDC says that IED blasts rising alarmingly in Jammu and Kashmir area rather than Maoist, Naxalite states.

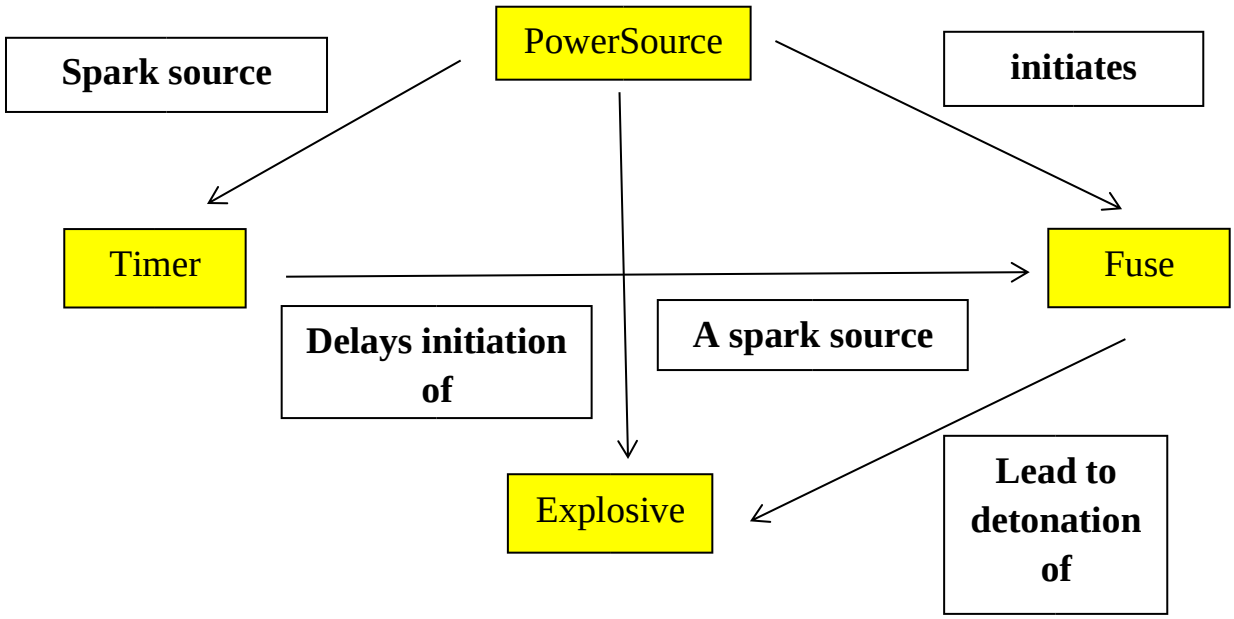
Components of Improvised Explosive Devices (IEDs)

The typical components that make up an IED and how they all function together are two critical pieces of knowledge every security personnel, investigators, or any other examiner or law enforcement agencies should understand. All IEDs generally require these mentioned four components :

- Power Source- basically it provides electrical charge to the detonator.
- Initiator- this contains a small amount of explosive material which triggers all other explosives contained.
- Explosives contained in the homemade lethal improvised device
- Switch or timer guides the initiator as to when the IED should be set off
- We can even consider the container which keeps everything in place as the fifth component of IEDs.

Examples of Power source are car batteries, flash light batteries, watch batteries etc.

Initiator can be blasting cap or any detonating device. Explosives include TNT(Tri Nitro toluene), PETN(Penta Erythritol Tetra nitrate), TATP etc. Switches can include car keys, any other keys, clock, timer etc. As a container, we can consider pressure cooker, any container, bags, suitcase etc.



TYPES OF IMPROVISED EXPLOSIVE DEVICES

As IEDs, being composed of a huge range of various components, and their appearance being well out of sight, it is much harder to be identified. Vidisco's portable X-ray solutions enables any bomb detection squad to detect all three types of IED, regardless of how the device is made.

Based on way the explosives are detonated, we can categorize IEDs in three types:

1. Time IED:

these IED makes use of a 'time switch' –it basically performs a countdown until the IED detonates. There could be the use of a mechanical or any digital clock. In more innovative cases, there could be use of an imaginative bomber like placing two electrical contacts separated by ice, which when melts will automatically lead to the contacts touching and the targetted explosion will occur.

2. Command IED:

As the name suggests, these explosives are operated by a bomber, be it tethered or non tethered. The only difference between the two types tethered and non tethered is that in tethered there is a physical connection to the bomber which can be any household object like lamp cord, telephone wires etc. On the other hand, non tethered connection is basically remote controlled or RCIED (Remote Controlled Improvised Explosive Devices).

3. Victim operated IEDs:

This is infact the most common types of IED, it is a victim operated bomb specifically built and created to explode when the victim will activate it. Various unconventional tactics, innovations may be applied for choosing components which will cause the detonation. Suspicious findings may include a switch, trip line, wire etc.

EFFECTS OF EXPLOSION

1. Primary Effects:

a) Blast effects:

- the first phase of an explosion is the blast phase and maximum damage is caused by this effect.
- during detonation of any high explosives, the solid or liquid explosives gets converted into extreme hot gas,which expand rapidly making the surrounding air to compress and forming a shock wave.
- fast movements of the gases hence create a pressure blast wave or shock wave as high as 700 tonnes/sq.inch. The blast wave can travel at a speed of 13000miles/hr.
- the initial blast of the outward movement is referred as positive phase as the explosive pressure can tear apart anything and everything that comes its way. The second effect of this blast effect is referred as the negative phase, occurs when pressure from the positive phase extends outward from the explosion.

b) Fragmentation effect:

The second phase is known as fragmentation effect, where the container of the exploding material is destroyed. In case explosive is filled in a metallic container, additionally certain nails, bolts or any sharp objects are added with the explosives to make the aftermath of the explosion more fatal and lethal. The destruction power of the explosive increases by significant times. These fragments tend to travel at a speed of upto 6000 km/hr after the blast. Many fragments even travel faster than the bullets, as a result injuries reported are more in number.

Better fragmentation effect can be achieved if the bomb's body is pre fragmented as in the case of grenade or may be if the bomb is designed as such to fly away the fragments after blast in a specific direction.

c) Thermal effect:

This is the final phase of the explosion. In thermal effect, heat is generated post blast but the heat varies with the lethality of the explosives. Generally it is noticed that fire emerges after post blast due to high temperature as explosion is exothermic in nature. Even fire can be seen at places where the fragments of the blast drop.

The rate of heat released and the temperature depends on the type of explosive, amount of explosive material used, distance of the blast from the area where the fragments dropped, and the speed at which the explosion was occurred. The temperature at the time of explosion could be anywhere between 3000-4000 degree celcius depending upon the nature and quantity of explosives used. At such high temperature it is obvious that the person will be charred to death.

2. Secondary Effects:

When the explosion takes place, the after blast residues, fragments cause fire and as a result release gases which might rupture electricity, water sources, pipes, electricity poles which inturn can create huge damage to lives around.

3. Tertiary Effect:

Human body, injury concerns of humans as a result of which there might be fracture,traumatic amputation, brain injuries, trauma etc.

4. Quaternary effect:

Everything other than those under primary, secondry and tertiary effects are categorised under this effect.

Physical damage to humans due to explosion pressure

1. 10-25 KPa:
   - temporary hearing loss
   - 50% chance of ear drum rupture
   - Possible injury from fragments, debris, glass pieces etc..
2. 25-75 KPa
   - 100% possibility of eardrum rupture
   - Serious injuries from fragments, debris released afte blast
3. 75-200 KPa
   - Death or fatal injuries due to damage of lungs from building collapse, debris etc.
   - Primary shock waves can cause mild traumatic brain injury, direct injury to head may also occur due to flying debris.
4. Above 200 KPa:
   - Death due to rupture of lungs from direct blast.

Physical damage on properties due to blast

1. 10-20 KPa
   - Glass frame fracture
   - Light superficial damage
   - Minor structural damage
2. 20-40KPa
   - Light to medium structural collapse
   - Glass doors, windows ruptures as a result of which injuries reported
3. 40-70 KPa
   - Moderate to severe damage to non reinforced buildings, structures.
4. 70-120 KPa
   - Moderate damage to reinforced building, structures
   - Severe damage to non reinforced building, structures
5. 120-300 KPa
   - Collapse of structures, massive damage to nearby surroundings.

DETECTION OF IEDs

How IED is built is not much known so common disposition methods like those used during demining might not prove beneficial Before disposing IEDs the sapper should incorporate all available methods to study its design, although there remains no real time for study when dealing with IEDs..if the IED is equipped with a timer.

The pin point location, nature and amount of the explosive charge used in the explosive might not be determined by external survey. Triggering mechanism of IED can be initiated at any given time.

Improvised explosives used in IEDs, are very unstable at most times , they remain super sensitive to a small external pressure, shock, temperature or even touch.

Mostly used high explosives in IEDs can be divided into 5 divisions:

1. Those that are produced for defence purposes used by security forces like TNT , C4 have high stability and have better regulated sensitivity to external factors, these also possess higher density than most other organic substances. 2. Those explosives which are used for civilian purposes like grammonite 50/50, ammonite are often mixtures of milititary explosive substances like Tri Nitro Toluene with substance like ammonium. These explosives are intensely explosive, densities ranging 0.9-1.2 g per cm3 ,almost

similar to commonly occurring organic substances. Moreover these explosives has a promoter which enhances these devices to get detected by vapour analysis.

3. Bombs made from materials available with ease being used in civilian activities like ammonals, igdanites are easily manufactured onspot as the components are cheap and easily available. These prove to be rather highly explosives as the capacity of explosion of igdanites is half to that of TNT.

   These have densities close to commonly found organic substances, these also possess high minimum detonating mass. These explosives are packed tightly and sealed so that the liquid components does not evaporate and the shell life increases.
4. Explosives used by terrorists made at home having illegal key to explosieves like “Chechen Mix which is for military use which is a mixture of “Ammoniac saltpeter” , bit sugar, then alluminium powder and finally RDX.
5. Explosives built from variably available components like Triacetone triper oxide (TATP) Hexa-methylene Tripe oxidediamine(HMTD) are cheap, have less detonating mass, allowing production of IED of varying explosives . these also have have average density similar to organic substances, but unstable and highly unpredictable as they instantly bursts on even storage so these are tightly packed and closely air tight packed by paraffin to stop evaporation and to enhance life. while industrially-produced explosives are stable and require a detonator, there are IEDs with unstable explosives which can be initiated without a detonator so lack of this makes the IED detection by X Ray quite challenging.

Overall IED detection methods can be classified as follows:

- detection of IED components not explosive
- detection of vapours of explosive substances
- detecting bulk amount of Explosive substances

1. How to Detect not explosive IED substances:

commonly used methods are:

- Unit X rays which are easy to carry: to find out the construction and built of the IED under scanner. The benefits underlying this method is
  - High penetrating ability about 2-3 cms of steel
  - best resolution providing detailing picture of the explosive device.

However, x-ray equipments require dual sided accession to the device suspected, they cannot separate types of components, as a result this method is unable to differentiate a dummy IED to a real one.

- "Non-linear junction detectors": these detect junctions in metallic, semiconductors which can trigger or control IED. By this we can also detect radio controlled IEDs. This method is
    - Fast with real time work
    - Has a detection range of about 10 m.

However, this method cant differentiate between circuits which are part of the mechanism.

2. Detection of vapour and traces of explosions:

Different explosives contrast from one another in instability. Instability is the strain of soaked fumes which are close to the outer layer of the unstable, and is by and large communicated as relative centralization of atoms of the hazardous substance and that of the particles present in air in a specific volume. The fume tension will drop assuming that the IED is fixed, which is the case for the most part, it can additionally decrease in low temperatures like the centralization of TriNitroToluene drops by a variable of 2 with 5degree decrease in temperature. To build the fume fixation inside the recognition gadget remarkable kind of preconcentrators are deviced, which siphon through air and retain hazardous substances. The Devices for fume examination can likewise be utilized to dissect hints of the explosives utilized in the IED. For this situation the outer layer of the thought object is cleaned by an exceptional napkin, which is then positioned in the location gadget, where the atoms are conveyed to the locator through stream of transporter gas.

RDX, PETN and many more Explosive substances can be identified by vapour methods currently being performed by biological, chemical and electrified sensors.

Biological sensors

Dogs, rats, bees, antibodies are being used for detection of the explosive substances. Dogs and antibodies are mainly used in metropolitan cities, while rats, rodents been used for detecting mines in local side areas. Canines can easily detect Explosive substances industrially made. Antibody based Techniques is the use of any specific antibody with some specific protein molecules which will selectively react with substances like TNT.

Antibodies are to be kept on the crystal's quartz surface , If any element exists, the antibodies bind with the molecules and exit from crystal's surface resulting in weight reduction which is hence calculating how

much shift has the frequency of the crystal. This mechanism is used for detecting vapours of various military Explosive substances like Tri Nitro Toluene, PETN, and RDX.

The advantage of bio-sensors lies in the practical exposure of their application.

The drawback being the number of explosive substances which can be detected is constricted. While assortment of explosives can be utilized in IEDs, canines are regularly prepared to track down just a set number of Explosive substances.

3. Detection of Bulk Explosives:

Detection of bulk explosives or macro particles in explosives in macroscopic quantities is done by active methods like passing through penetrating radiation waves like micro-waves, X rays, gamma rays, and particular substance in the explosive reacts differently to wave and gets detected.

Radars

These analyse the suspected object with electro magnetic waves like microwaves after which the results of scattered waves presents an image of concealed object and the di electric characteristics can be determine. Electromagnetic methods of IED detection are complete safe for objects and humanitarian. However these cannot detect explosives which are covered or wrapped up with any metallic coating, but the presence of the coating can be determined.

Hand held Ground Penetrating Radar

These systems are used in detecting anti tank mines, landmines (metallic or non metallic) and Explosive devices dumped in ground. Ground Estimation, Clutter Suppression, Detection of buried objects, their classification, alarming bells, and visual display of the system. Hand held GPR tends to be very useful in all areas like jungles, forests, inaccessible roads etc. This device also utilizes low power consumption. The ease at which the operating system works, the results are also presented on the screen which will allow the security personnel to take necessary actions. This device alerts the user about possible anomaly by sending signals.

Hand held GPR is generally configured on a 160cm collapsible wand. Wand is adjustable which makes its use easy during search operations, the operator can even conduct search operations by kneeling or lying down on the ground. An antenna is attached at the end of the wand which is close to the surface or ground. Electrical devices comprising of radar sub system, signaling data and image processing card is kept in an electronic box which is fixed at other end of wand. A human machine interface and a display screen are mounted on the handle for getting a 2D view of the

Case Study- 1 Explosion at Concept Sciences

Location: Allentown, Pennsylvania

Reason for explosion: High concentration & Temperature

Date: February 9, 1999

Casualties: 2 Killed, 4 bad injured, and some casualties

On February 9, 1999, at approximately 8.14 p.m., a case explosion occurs. With 100 pounds of Hydroxylamine, this explodes at Concept Sciences in Allentown, Pennsylvania (HA). Employees were distilling potassium sulphate and HA as an aqueous solution. Because the piping decomposes after the distillation process, the explosion is mostly caused by high concentration and temperature. Two CSI employees were killed on the scene as a result of the explosion. Four persons were seriously hurt in the vicinity. During the rescue, six firefighters and two security guards were hurt. Some surrounding homes and structures were also destroyed.

Case Study- 2 Olympic Park Bombing

Location: Georgia

Reason: Improvised explosive Devices

Date: 1996

Casualties: 2Died

The incident happened in Atlanta's Centennial Olympic Park in 1996. The IED (improvised explosive device) utilized in this blast was a pipe bomb. The explosion resulted in the deaths of two people and the injuries of many more. The perpetrator of the Olympic Park bombing, Eric Rudolph, subsequently adopted the moniker Olympic Park Bomber and pleaded guilty. He then launched a bombing campaign across the southern United States.

Case Study 3- Oklahoma City Bombing

Location: Oklahoma

Reason: Truck bomb

Date: April. 19, 1995

Casualties: 169 died

The bombing in Oklahoma City occurred on April 19, 1995. This occurred just in front of Alfred P. Murray. Oklahoma City is home to the Federal Building. The IED was made up of ammonium nitrate fertilizer and nitro methane, and it was placed in the back of the truck and detonated. 169 people were killed and many more were injured in this attack. By that year, it had been the worst terrorist strike ever.

Case Study 4- London Bombing

Location: London

Reason: Suicide Bombers

Date: 7 July 2005

Casualties: 52 Killed

The London bombing was carried out by a group of four suicide bombers armed with TATP IED explosives. They determined that the hazardous material is TATP after analysing the sample they obtained from the London premises. This occurred on July 7, 2005, in front of the London public transportation system. This disaster claimed the lives of 52 individuals and injured hundreds more.

Case Study- 5 Jagadhari Explosion

Location: Jagadhari Railway Workshop

Reason: Kerosene oil

Casualties: 78 Deaths

This incident occurred at the Jagadhri Railway Workshop when a fire broke out near the lunch area. The fire was started by the spraying of kerosene oil, according to the investigation team. However, the police superintendent does not believe the kerosene is to blame for the explosion. As a result, the investigating team questioned the lab experts again. Later, they discovered that some explosives were set off in the laboratory, causing the fire to spread to the lunch area. This was validated by the I.O investigating team as the source of the problem.

Case Study 6- Assam Rifles IED blasts

Location: Manipur

Reason: IED were detonated

Date: Jan 05, 2022

Two improvised explosive devices (IEDs) were detonated in Thoubal district on Wednesday, killing one Assam Rifles jawan and injuring another.

On Wednesday, the incident occurred at LilongUsoipokpiSangomsang in Thoubal district.

"The 16 battalion of Assam Rifles were patrolling while there was a blast," a police official who did not want to be identified told ET.

Case Study 7- Jharkhand IED blast kills 3 security personnel

Reason: IED blast

Date: Mar 04, 2021

Officials say three security officers were dead and two others were harmed in a Naxal-triggered IED in the West Singhbhum district of Jharkhand on Thursday.

Three members of the state police's special unit, the Jaguars special unit,, were murdered in IED blast in Hoyahat village at about 8:45 a.m.

Case Study 8- Pulwama: Indian Army convoy targeted with IED 9 jawans, 2 civilians injured Reason: IED blast

Date: Jun 17, 2019

The vehicle convoy of the 44 unit R Rifles was going on the Arihal-Pulwama course when the assailants detonated an explosive device, harming the army personnel in a projectile and-mine-confirmation Casper vehicle, as per them.

Armed force powers jumped right into it immediately, terminating in the air to oversee what is happening and obstruct any unexpected assault, as per authorities.

Case study 9- HNLC IED blast Two injured

Location- Shillong

Date-10th aug, 2021

Reason-IED blast

On Tuesday, suspected militants from the outlawed Hynniwtrep National Liberation Counsil (HNLC) detonated an explosive device in IewShillong, Laitumkhrah, injuring two people.

Conrad K. Sangma, the Chief Minister of Meghalaya, tweeted, "We strongly condemn the IED explosion that occurred in Laitumkhrah earlier this afternoon, injuring two people. @LahkmenR, the Home Minister, and @MeghalayaPolice authorities have informed me of the situation, and additional inquiry is underway ".

"Today at about 1:30 PM, received information that a bomb occurred at Laitumkhrah market near a Tea Shop located in the Parking Lot," the East Khasi hills district police said. Bomb Squad, immediately. Evidence was collected at the P.O. by the Crime Scene Unit and the Dog Squad. It was determined during the preliminary inquiry that the blast was caused by L.E.D."

Case Study 10- Chattishgarh IED blast, Deputy Commandant, 4 CRPF men injured

Location: Chhattisgarh

Reason: Pre planned by Naxals

Date: 8th feb,2022

Casualties: 4 Injured

An Explosive Device placed by Naxals in Chhattisgarh's Bijapur locale in Tuesday, harming four Central Reserve Police Force (CRPF) troopers, including an appointee commandant and an associate sub-investigator, police said.

153 rd troop of CRPF's contingent was on an mastery procedure on the Murkinar street under the Modakpal police headquarters region at 3 p.m., the occasion happened, as per IGP (Bastar range) Sundarraj P.

The watching crew, which had begun the activity from its Chinnakodepal camp, was cordoning off the backwoods along Murkinar street, around 450 kilometers from Raipur, when they came into contact with a strain IED (a custom made gadget), which detonated, he asserted.

CONCLUSION

Improvised Explosive Device has widely been used by insurgents, maoists, terrorist to carry out terror in bigger number. Having said that the raw materials used to make IEDs are so easily available and the procedure for making IED being so simple makes these devices as a choice for these activities. With time, the demand and popularity of these explosives will keep on increasing. However all paramilitary forces especially those deployed at highly vulnerable maoists affected areas and military forces should be aware and remain several steps ahead of these insurgents, so that their plans can be stopped from getting executed and the intended harm and tension they want to spread in the area is not achieved. These security forces must be made to go through rigorous training and hand on experience of how to cut off the depth of massive harm these explosives create so that none to minimum loss of peace and harmony occurs in the area. In recent days, insurgents come up with high uniquely built IEds which are almost unnoticiable, so these security forces must be made aware of all such latest trends of IED blasts.

Keeping this vision infront, Honorable Home Minister inaugurated the Institute of IED Management at Pune which acts as the centre for training paramilitary and police forces to deal with these highly vulnerable and lethal explosives.

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