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DESIGNING AND FABRICATION OF CRASH BARRIER

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ABSTRACT - Now a days, safety and security measures are not enough to provide protection from the threats the society is facing. A security guard in front of a gate cannot handle the unexpected situations like a speeding vehicle entering secured premises. So, there must be an effective and easiest way of improving safety in major protected areas like Military bases, VIP camps, Political leaders and Business men's houses, etc. With less cost crash barriers can be used with no time consuming and low risk and less injuries. The project here is to design and fabricate a crash barrier prototype which helps in some threatening situations as mentioned above. A crash barrier is a heavy metal plate which is fixed with an actuation system. In emergency situations with the help of a single button the barrier gets erected and blocks the pathway. SOLIDWORKS is employed for designing the crash barrier and with high reliability and low maintenance the prototype system is fabricated. The crash barrier system consists of Barrier, Gears, shafts, bearings, hinges, motors, plates etc., to lift the barrier and strong reinforcement to hold / stop speeding vehicle entering secured premises. A small destructive type test was done to the prototype and the results shown were satisfactory.

Further this project can be developed by automating the system with sensors and integrating the operation of hydraulic system to a computer control panel.

INTRODUCTION:

Crash barriers are among the most versatile physical security products on the market because of their compact footprint and robust design. They provide maximum security for high-threat locations especially those with potential high-speed impact conditions, limited response times and minimal property setbacks. The mechanical crash Barrier boasts a 41-inch deployment height for added protection against vehicles with a higher chassis and offers pleasing aesthetics, quiet operation and efficient installation.

The Mechanical crash Barrier is comprised of a high-quality, structural mild-steel frame and aluminium plate that, when raised, creates a flat barricade to seal off roadways and prevent vehicle access. The design of the crash barrier is very popular because it effectively transfers high impact loads into a relatively compact foundation. Yet remarkably, this barrier only requires 16-inch (400 mm) deep excavation and 3 cubic yards of concrete, which shortens installation time and reduces cost. A Mechanical gearing unit (MGU) operated with the help of 1HP electric motor is housed in the deep excavation controls the enclosure and activates the barrier, lifting the plate in 5 seconds for normal operation and 1.5 seconds in Emergency Fast Operation (EFO) mode by pressing a single push button .The Mechanical Crash barrier is available with many equipment options for managing operation including control consoles, traffic equipment, safety loops and environmental controls. Because all of the equipment is near ground level, this barrier is easy to maintain. This Mechanical Crash barrier is ideal for the following conditions.

- **High-speed impacts** where the roadway layout allows vehicles to reach higher speeds
- **Minimal setbacks** where critical assets or equipment are located close to entrances (such as in urban areas) and a high level of security is required regardless of potential vehicle speed
- **Fast deployment** where the barrier needs to be deployed quickly because it is located close to the guard booth and reaction time is therefore minimal
- **High traffic** used as a final denial, this barrier can be used in tandem with standard traffic arms to process a high number of vehicles faster than other barrier types
- **Site restrictions** where flush mounting with the roadway surface is required for snow plowing or where buttresses and posts used in other barrier designs would prevent access for wide vehicles
- **Bicycle/motorcycle access** where preventing access by two-wheeled vehicles is desired
- **Excavation limits** where underground utilities, high water tables or other site conditions limit excavation depth
- **Space restrictions** where there is not enough room for beam-style barrier buttresses and foundations
- **Debris buildup** where debris accumulation can cause operational issues

The Crash Barriers are the most proven, tested and reliable vehicle-access control barrier systems in the world. They are a perfect combination of engineering achievement, durability and security. Absolutely no substitute comes close to the advantages offered by the Mechanical Crash Barrier Systems

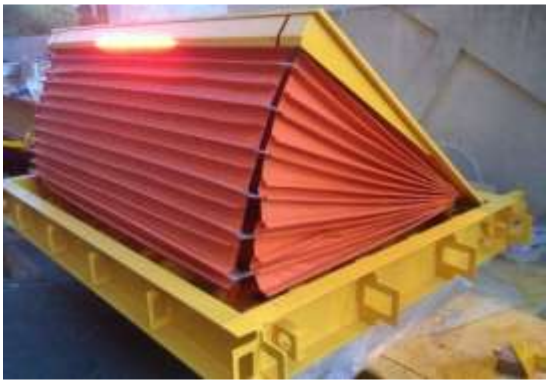


Fig Side View of Crash Barrier.

Fig Front View of Crash Barrier

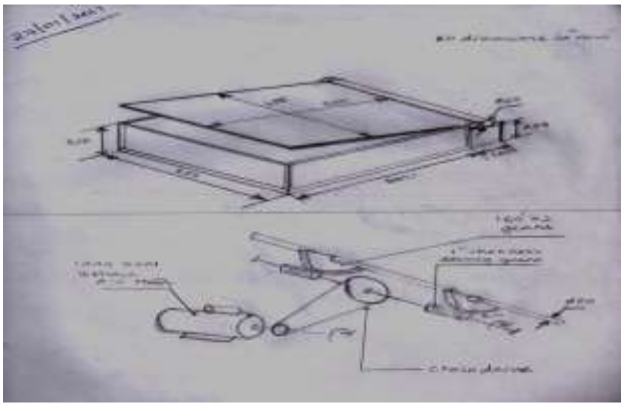
Mechanical Crash Barrier provides crash tested security for high-threat and demanding environments while minimizing visual and audible impact to the surrounding area. It also has minimal foundation requirements, Emergency Fast Operation (EFO) and continuous-duty rating, making this barrier ideal for broad range of high-security facilities such as embassies, military bases, nuclear power plants, refineries and airports.

Crash barrier in India:

Most of the barriers used in India are not crash barriers they are boom barriers, hydraulic based barriers are very rare to find they are not seen at regular civilians area they are only available at high security zones. Equipping the crash barriers to some high security zones will give more reliability to the security system.

Fig Front View of Crash Barrier

INITIAL DESIGN:



DESIGN SPECIFICATIONS:

Length of the metal frame = 820 mm

Width of the metal frame = 650 mm

Height of the metal frame = 320 mm

Aluminium chequered plate dimensions:

Length of the plate = 800 mm

Width of the plate = 650 mm

Bearings requirements:

Type of bearing = Ball bearing

Diameter of bearing = 20 mm

Number of bearings required = 4

Counter-mass basket dimensions:

Length from pivot bearing = 430 mm

Length of angle used in building the basket = 150 mm

Number of angle pieces = 5

Chain drive:

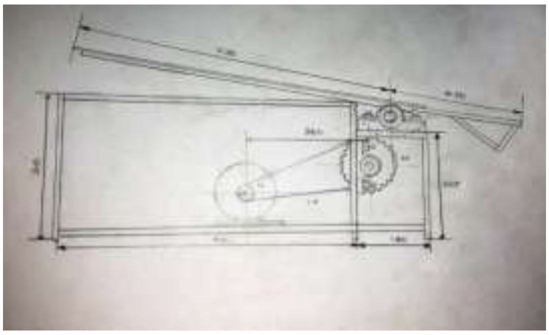
Pinion diameter = 35 mm

Number of teeth on pinion = 13

Sprocket diameter = 80 mm

Number of teeth on sprocket= 39

Gear ratio = 1:3



Gears used:

Driving gears:

Material used: EN8

Diameter of gear = 60 mm

Bore diameter = 20 mm

Thickness of the gear = 25.4 mm

Number of teeth = 28

Number of gears used = 2

Driven gears:

Material used = EN8

Diameter of gear = 34 mm

Bore diameter = 20 mm

Thickness of the gear = 25.4 mm

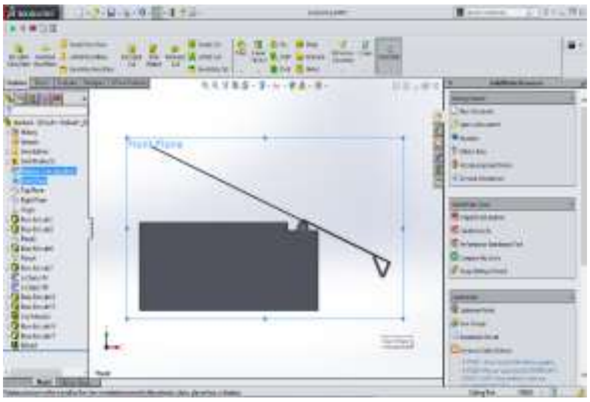
Number of teeth = 38

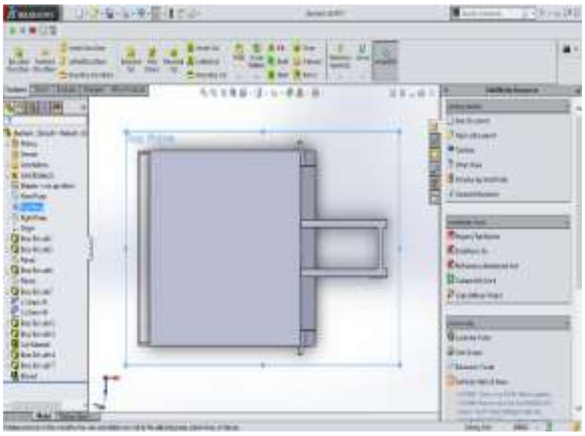
Number of gears used = 2

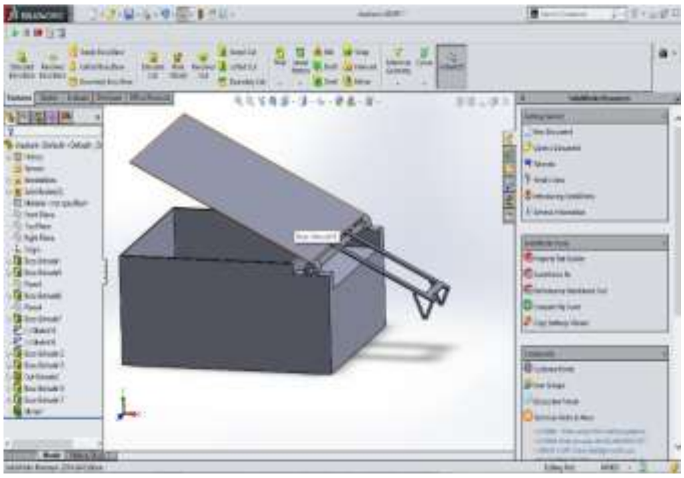
3D-MODELLING:

The software used in modelling crash barrier is Solid Works.

External frame:

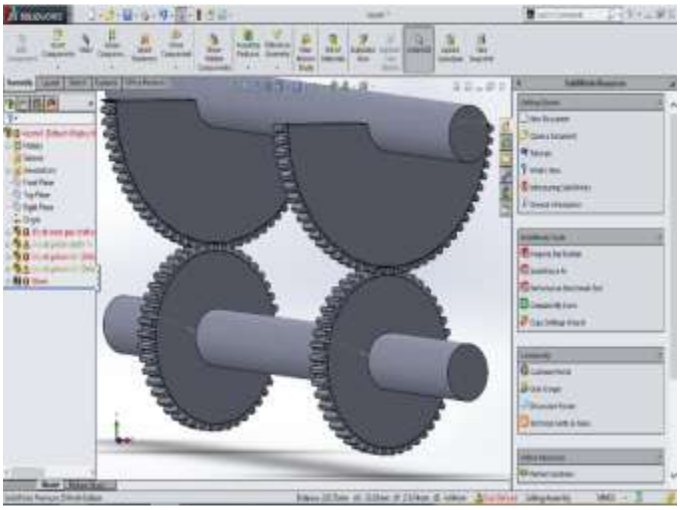


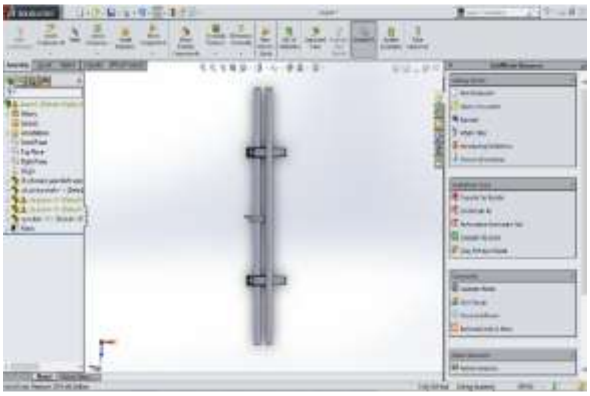


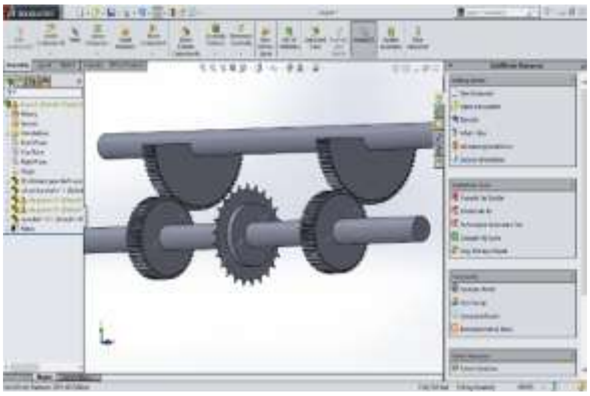


Gear meshing:

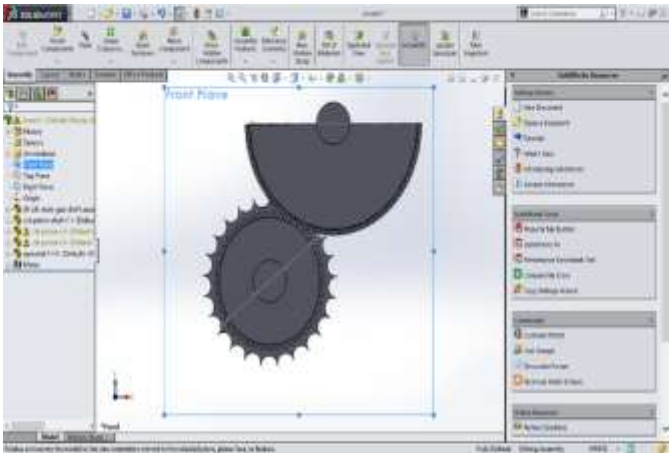
Arrangement of gears with shafts and meshing of driving and driven gears.







Gear arrangement after assembling sprocket:



DESIGN CALCULATIONS	REAL -TIME CALCULATIONS
SPEED CALCULATION: • Length of the corridor(L)=60 M(assumed) • Vehicle speed (S)= 100kmph • Velocity of the unauthorized vehicle (V)=$\frac{1000}{60X60} * 100$=27.7 m/s • Time required for the unauthorized vehicle to hit the door(t1)= $\frac{lengthofthecorridor}{velocityofthevehicle}$=$\frac{60}{27.7}$=2.16 secs • Time required for actuating the push button(t2)=2secs (assumed) • Angle rotation of main shaft for lifting crash barrier to stop the unauthorized vehicle (θ)=60^0 • Required speed of main shaft(s1) =$\frac{60*\frac{\upsilon}{360}}{t1-t2}$ =$\frac{10}{0.16}$=62.5 R.P.M • Design margin(DM)=100%	**SPEED CALCULATION:** • Length of the corridor(L) = 60M(assumed) • Vehicle speed (S) = 100kmph • Velocity of the unauthorized vehicle (V) = $\frac{1000}{60X60} * 100$ = 27.7 m/s • Time required for the unauthorized vehicle to hit the door(t1) = $\frac{lengthofthecorridor}{velocityofthevehicle}$ = $\frac{60}{27.7}$ = 2.16 secs • Time required for actuating the push button(t2) = 2secs (assumed) • Angle rotation of main shaft for lifting crash barrier to stop the unauthorized vehicle (θ) = 60^0 • Required speed of main shaft(s1) = $\frac{60*\frac{\upsilon}{360}}{t1-t2}$ = $\frac{10}{0.16}$ = 62.5 R.P.M • Design margin(DM) = 100%

- Required speed of main shaft considering the design margin=(s1)X(100+DM)=62.5X(100+100)= 62.5*(200%)=125RPM

MOTOR SELECTON:

Motor selected=1 HP/1450 RPM(4-pole A.C motor 230 volts single phase)

SPEED REDUCTION:

stage 1:

- no. of teeth on pinion=13
- no. of teeth on sprocket=39
- gear ratio=$^{13}/_{39}$=1:3
- speed reduction=1450X$^{1}/_{3}$=483.3RPM

stage 2:

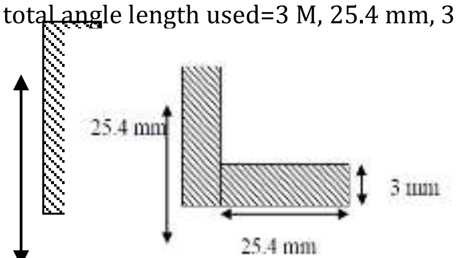
- no. of teeth on pinion=28
- no. of teeth on gear=76
- step down in second stage=$^{28}/_{76}$=0.368≅ 1: 3
- speed reduction in 2nd stage=483.3X$^{1}/_{3}$=161.1RPM
- As the speed of the main shaft after 2nd stage reduction is higher than the required speed the selected motor and gear ratios are satisfactory.

POWER & COUNTER MASS CALCULATION:

Let's take the main shaft as the reference point for calculating the mass and volume.

MASS BEFORE SHAFT:

- total angle length used=3 M, 25.4 mm, 3



- mm,
- area=$\frac{25.4X2X3}{1000000}$=0.000152 m^2
- volume(V)= area * height=0.000152*3=0.000457m^3
- density of mild steel= 7600 kg/m^3
- density(ρ)=$\frac{mass}{volume}$=$\rho *$ v=m=7600*0.000457=3.44732 kg

- Required speed of main shaft considering the design margin=(s1)*(100+DM) = 62.5*(100+100) = 62.5*(200%)= 125RPM

MOTOR SELECTON:

Motor selected = 10 HP/1500 RPM(4-pole A.C motor 230 volts Three phase)

SPEED REDUCTION:

stage 1:

- no. of teeth on pinion = 13
- no. of teeth on sprocket = 39
- gear ratio = $^{13}/_{39}$ = 1:3
- speed reduction = 1450*$^{1}/_{3}$ = 483.3RPM

stage 2:

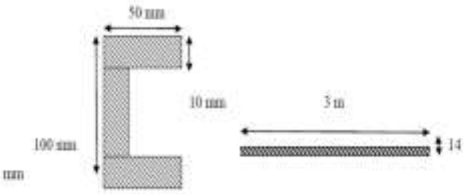
- no. of teeth on pinion = 28
- no. of teeth on gear = 76
- step down in second stage = $^{28}/_{76}$ = 0.368 ≅ 1: 3
- speed reduction in 2nd stage = 483.3*$^{1}/_{3}$ = 161.1RPM
- As the speed of the main shaft after 2nd stage reduction is higher than the required speed the selected motor and gear ratios are satisfactory.

POWER & COUNTER MASS CALCULATION:

Let's take the main shaft as the reference point for calculating the mass and volume.

MASS BEFORE SHAFT:

- total angle length used = 9.14 M



- area = $\frac{10*50+80*10+50*10}{1000000}$ = 0.0018 m^2
- volume(V) = area * height = 0.0018X9.14 = 0.0164 m^3

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CHEQUERED PLATE MASS:

plate(1) plate(2)

- area=(0.65X0.82)+(0.58X0.4)=0.765 m^2
- volume=area * height= $\frac{0.765X5}{1000}$=0.003825 m^3
- density of aluminum=2800 kg/m^3
- mass(M)=$\rho * v$

= 2800X0.003825=10.41 kg

- total mass(T)= 3.44732+10.41

=14.15 kg

MASS BEHIND THE SHAFT:

- length of angles used=2.34 M
- area=0.000152m^2
- volume=0.000357 m^3
- density=7600 kg/m^3
- mass(m)=$\rho * v$=2.7132 kg
- mass added to balance= 7 kg
- total counter mass=9.7132 kg

FORCE CALCULATIONS:

- force acting on the bearing

because of crash barrier = total mass * g

= 14.15 * 9.81

=138.81 N

- force acting on the bearing

because of counter mass = total mass * g

= 9.7132 * 9.81

= 95.28 N

- density of mild steel = 7600 kg/m^3
- density(ρ) = $\frac{mass}{volume}$= $\rho * v = m$

= 7600X0.0164 = 125kg

CHEQUERED PLATE MASS:

- area = (7.5*0.82) = 6.15 m^2
- volume = area * height = $\frac{6.15X10}{1000}$ = 0.0615m^3
- density of Steel = 7800 kg/m^3
- mass(M) = $\rho * v$

= 7800*0.0615 = 479kg

- total mass(T) = 125+479 = 604Kgs

MASS BEHIND THE SHAFT:

- length of angles used = 4 M (assumed)
- area = 0.0018m^2
- volume = 0.0018*4=0.0072 m^3
- density = 7600 kg/m^3
- mass(m) =$\rho * v$ = 7600*0.0072 = 54.80kg
- mass added to balance = 500Kgs
- total counter mass = 554 Kg

FORCE CALCULATIONS:

- force acting on the bearing

because of crash barrier = total mass * g

= 604 * 9.81 =5919.24 N

- force acting on the bearing

because of counter mass = total mass * g

= 554 * 9.81 = 5429.2 N

- total unbalanced force = 5919.24 - 5429.2

= 490 N

- radius of crash barrier = 0.82 M
- force(unbalanced) = 490 N

TORQUE CALCULATION:

- torque(T) = 490*0.82 = 401.8 N-m
- speed of the main shaft(N) = 161.1 RPM

POWER CALCULATION:

- total unbalanced force= 138.81-95.28

  = 43.58 N

- radius of crash barrier= 0.82 M
- force(unbalanced)=43.58 N

TORQUE CALCULATION:

- torque(T)=43.58*0.82=35.7356 N-m
- speed of the main shaft(N)=161.1 RPM

POWER CALCULATION:

- power = $\frac{2\pi NT}{60}$

  $=\frac{2*\pi*161.1*35.7356}{60}$=602.87 W

- design margin considered=10%
- total power required=power * (100+DM)%

  = 602.87*(100+10)%

  =663.157 W

- As power of the motor selected is higher than required the selected motor is satisfactory.

- power = $\frac{2\pi NT}{60}$

  $=\frac{2*\pi*161.1*401.8}{60}$ = 6774.3 W

- design margin considered = 10%
- total power required = power * (100+DM)%

  = 6774.3 * (100+10)%

  =7.45 KW

- The real time calculations are developed by assuming width of the road as 7.5 meters. These can be altered according to width of road.

WORKING PROCEDURE:

The crash barrier is stopping device which is embedded into the earth in such a way that the upper metal sheet is visible and the structure is within the road surface. The barrier is simple in working, the motor is wired in such a way that the power is directed through a forward and backward switch to a push button. So when un-authorized vehicle is approaching the main gate the guide is given access to the push button, With a single push of this button the barrier lifts up as the power passes though the switch to the motor which in turn rotates the chain drive which rotates primary shaft on which the driving gears are welded, The driving gears then turn the main shaft to which the upper frame is welded, Which finally lifts the plate and blocks the road and avoids the vehicle to pass that point and holds it as the barrier will be in the width of the road.

CONCLUSION:

The crash barrier with a mechanical system is easy to access. As it does not use hydraulic power unit it requires low maintenance and comparatively low cost for manufacturing, the parts and raw materials used in the project are all procured within the nation so there is no issue in mass production of these barriers. Our intention is to design and built a crash barrier which can be used in every demanding environment like shopping mall, schools, hospitals, theatres and also high threat areas like military bases, nuclear power plants, refineries and airports. Our crash barrier is operated by using gear mechanism, the gears used are spur gears with stub involute profile and a chain drive which is connected to A.C motor by which a lift of about 65 degrees is obtained. In order to reduce load on the motor, counter load about mass of 9kg is used. Use of mechanical gears has reduced the price of crash barrier, further replacement of hydraulic power unit with the mechanical system reduces the size of the project which is can made available cheaply and considering the drawbacks of hydraulic system, there is no issues about leakages and overshooting in this mechanism compared to hydraulics. Replacement of hydraulic cylinders with gears basically clears up lots of space and mainly removes fluid system from the mechanism which reduces loses and reduces the costs of maintaining it and also keeps the enclosure safe as in case of hydraulic system when there any sort of leakage then the enclosure gets spoilt and the oil might tend to enter electrical system as well.

REFERENCES:

- Joe Browning, Manuela Velosoet all discussed that crash barrier is a dynamically physical security system which can prevent a fast moving unauthorized vehicle into our premises.
- John David Warner and B. Gabriel Taylor, barriers in call are discussed when used as an intended, the crash barrier is useful in preventing armed terrorists by the collision into our premises which can operated manually by the security guard
- Philips, Benjamin performed the crash tests and done analysis in order to know the resistance of the material that can withstand the amount of impact load on a beam, some of the civil engineers performed structural steel analysis in order to know the strength of the steel used for the project.
- Dr. Ron fang (Rachel) Liu, AICP, PE etc; all are discussing about the demand of crash barrier in order to make their physical security system more stronger and efficient The hydraulic crash Barrier is comprised of a high-quality, structural mild-steel frame and aluminum plate that, when raised, creates a flat barricade to seal off roadways and prevent vehicle access.