Equipments

Centrifuge

Figure 1 gives a brief sketch of the centrifuge at IWHR. As the centrifuge accelerates, the basket together with the model in it would gradually incline to the horizontal, namely, the larger the angular velocity of centrifuge ω, the greater deflection angle of the basket β (Figure 1). Therefore, an additional horizontal centrifugal acceleration, dozens of times larger than gravity, would be loaded on the model. Thus, the small-scale model would be with similar gravity field as the prototype when the Earth gravity is neglected and the centrifugal acceleration is uniform. And it is worth noting that the effects of Coriolis force have been demonstrated theoretically by Snay [1] that the deflection is relatively small when bubble migrates. The IWHR centrifuge provides a maximum centrifugal acceleration of 300g with a maximum rotation radius of 5.03m and payload of 150t.

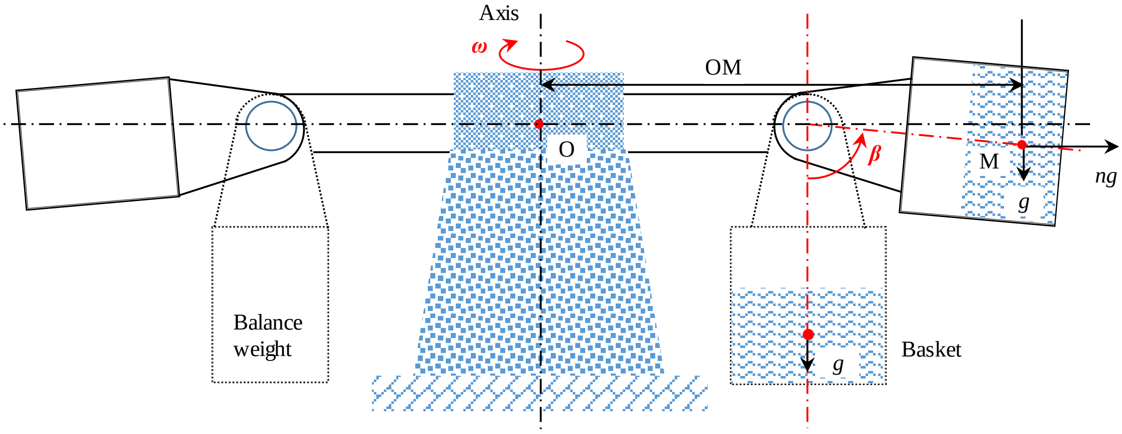

Figure 1 Sketch of centrifuge

Explosives

The RDX spherical explosives and micro detonators are specifically manufactured by the researchers to ensure precision in small quantity, as shown in Figure 2. The density of explosive is 1.65g/cm^3 and the detonation speed is 8160m/s. A 10cm long detonating fuse with a diameter of 2.6mm and TNT equivalent of 48mg/m is ignited by a micro detonator (RDX equivalent 50mg) to centrally detonate the explosive. In the experiments, three micro detonators were bundled together and connected in series to simulate the effect of 150mg detonator. The explosive is converted to TNT equivalent by a coefficient of 1.58.

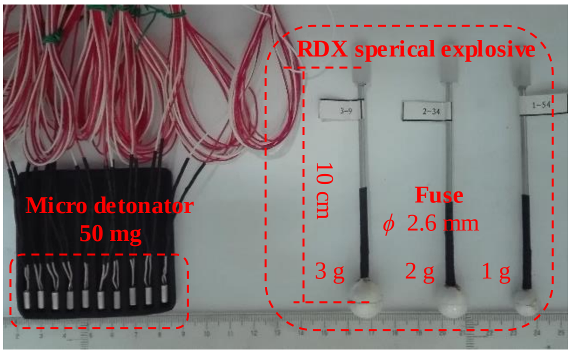

Figure 2 Micro detonators and RDX spherical explosives used in the tests

Monitoring

The facilities for recording the UNDEX responses includes:

(1) FASTCAM-ultima APX High Speed Camera for capturing the explosion images, especially UNDEX bubble oscillation in the centrifuge with a frequency of 2000 fps and resolution of 1024×1024.

Figure 3 High speed camera

(2) 138A10 Blast pressure sensor (range 0-68MPa, resonant frequency > 1000kHz, rise time < 1.5μs), made by PCB Piezotronics Inc for shock wave pressure measurements. In the tests, these sensor is placed at the same attitude with the center of explosive. Position of the sensor is adjusted in each test to vary its distance from the explosive.

Figure 4 138A10 Blast pressure sensor

(3) A data acquisition system, designed and built by the researchers with a maximum sampling frequency of 1MHz and maximum record time of 500ms. It is worth noting that the development of such a system in the centrifuge for synchronously measuring signals in 32 channels with high frequency and wide range during the detonation and explosion is the key point to the success of these tests.

(4) The strain gauges are of resistance type and, evenly applied in both horizontal and vertical directions, each has resistance of 120.1±0.2Ω and gauge length 5mm, with sensitivity index K=2.08±1% and allowable frequency 55 kHz. 1/4 Wheatstone bridge is used to measure the strain, connected to an amplifier with frequency response 100 kHz and low pass 100 kHz that is linked to the data acquisition system. The power supply voltage of the amplifier is 5 VDC ± 0.3%, which enhances the original signal by 1000 times.

(5) The PCB 350B01 accelerometers AC-1 and AC-2 have measuring range ±100000g, frequency response 1 Hz-10 kHz and resonance frequency greater than 200 kHz. Its weight is 4.45g and the size is 3/8in×18.4mm. The accelerometer AC-3 is of type PCB 350D02, with measuring range ±50000g, frequency response 1 Hz-10 kHz and resonance frequency greater than 100 kHz. Its weight is 4.5g and measured 3/8 in×19.1 mm. Three holes are drilled on the plate at the downstream side, where the 3 accelerometers are installed and tightly fastened to ensure the rigid connection.

(a) (b)

Figure 5 Accelerometers used in the test. (a) 350 B01; (b) 350 D02.

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