Development of Large Scale Testing Facilities and Cyber Infrastructure in Korea by KOCED Program

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SUMMARY:
Korean government launched Korea Construction Engineering Development Collaboratory Program (KOCED Program) in 2004 to develop a national research infrastructure. For the first phase of this program, six large scale testing facilities and cyber infrastructure (CI) system were successfully constructed in 2009. The second phase, in which 5 more new testing facilities are to be built, is going to start next year. Although KOCED program benchmarked NEES program, there are two major differences: to build brand-new large scale testing facilities and to include testing facilities which are not directly related to earthquake engineering, such as wind tunnel, material testing facility and ocean simulation testing facility. With the completion of Phase I of KOCED program, the Ministry of Land, Transport and Maritime Affairs (MLTM) established the KOCED Collaboratory Management Institute (KOCED CMI), a non-profit organization entrusted with operating and managing the six KOCED testing centers. In this paper, an introduction of KOCED program and cyber infrastructure as well as testing facilities is given.

Keywords: large scale testing facility, KOCED, earthquake engineering simulation

1. OVERVIEW OF KOCED PROGRAM

The Korea Construction Engineering Development Collaboratory Program (KOCED program) aims to promote research and development in the various fields of construction engineering by establishing a nationwide and comprehensive base for testing, research and education. In the current version of master plan of this program, total of 11 testing facilities are planned to be built in two phases. For the first phase, six large-scale testing facilities have been built at major regional universities evenly distributed around the country from 2004 to 2010. Basic planning of five more new testing facilities for the second phase has been being carried out since 2011 and main program is going to be launched on 2013. Total budget for Phase I was 70 million USD of which 50 million USD was invested by government and 20 million USD was matching fund by hosting universities. For the time being, total budget to be invested by government for the second phase program is approximately estimated as 107 million USD including overall management of construction of Phase II facilities and upgrade of Phase I testing facilities as well as CI system.

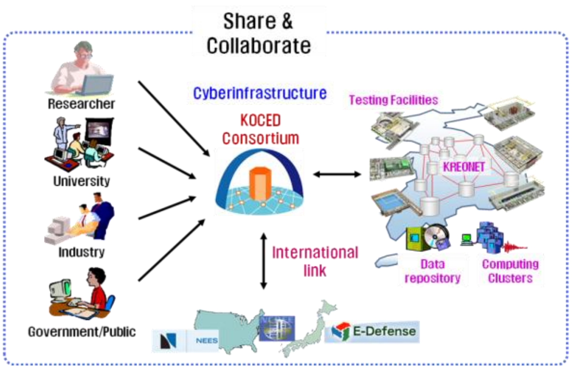

Figure 1. Vision of KOCED program

Developing a cyber infrastructure (CI) system which connects these testing facilities, large databases, high-performance computers, cutting-edge equipment, and other resources located across the country with a high performance information network is another main objective of this program. With this CI system, various services such as test reservation, data archiving and retrieving, remote monitoring, collaborative design, tele-presence and virtual laboratory, etc. can be provided to enhance collaborative research and eventually productivity of R&D investment.

Similar programs of other science and engineering areas in Korea, where large scale testing facilities were constructed for shared use, were frequently estimated as unsuccessful since most hosting institutes operate mostly for their own research purpose not for open and shared use. In order to avoid this problem, shared use of certain portion of the total operating time is a mandatory requirement to the hosting universities. A non-profit organization KOCED Collaboratory Management Institute (KOCED CMI) was established for integrated management and operation of testing facilities, operation and service of CI system, outreach through education and training programs, standardization of testing process as well as establishing international network of testing community.

2. PHASE I TESTING FACILITIES (COMPLETED)

Six large-scale testing facilities of Phase I and their hosting universities are shown in Figure 2. They are widely spread over the country to form the local center for relevant research.

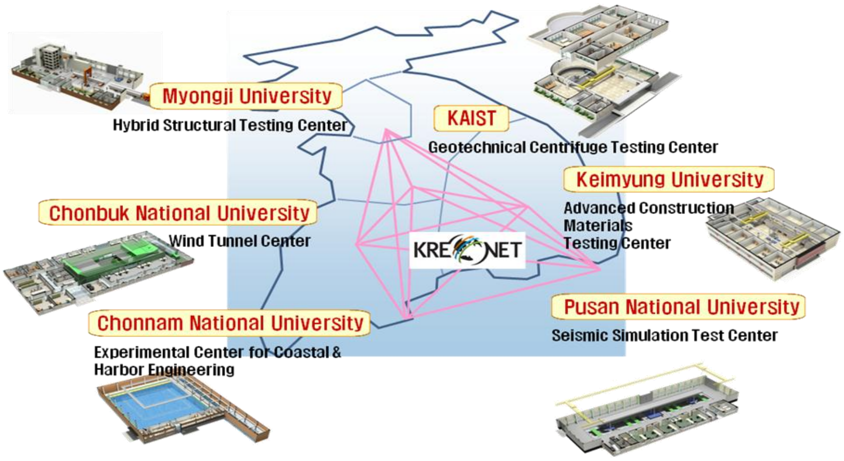

Figure 2. Six testing facilities of Phase I

2.1 Hybrid Structural Testing Center

Hybrid Structural Testing Center is located at Myongji University, Kyunggi-do. This facility has state-of-the-art equipment to perform real-time hybrid structural test as well as conventional structural performance test of multi-degrees of freedom structural systems and components. Overall shape and dimension of reaction floor and wall are shown in Figure 3. A staggered L-shaped strong wall has maximum height of 12m. If 48.9m long indoor strong floor and 3 outdoor strong floors are combined together, very long specimen up to 80m long can be tested. An array of actuators ranging from 250kN to 5,000kN powered by 720gpm hydraulic power supply can accommodate various testing needs of users. Among them, 250kN, 1,000kN and 2,000kN actuators are equipped with dual servo valves, small capacity for static tests which requires very small hydraulic flow control and large capacity for dynamic tests which requires high hydraulic pressure. Furthermore, every actuator has a long stroke so that they can make ductile specimens to reach failure status. In addition, 5,000kN dynamic and static UTMs are installed.

There have been many successful test cases since it started service. Among them, test cases of two different types of newly developed 60m long PSC bridge girders were worth-mentioned. One type in Figure 3 was made monolithically, while the other type was fabricated in 5 pieces and assembled on site, and both girders were tested statically and examined whether they satisfied design assumptions and code requirements.

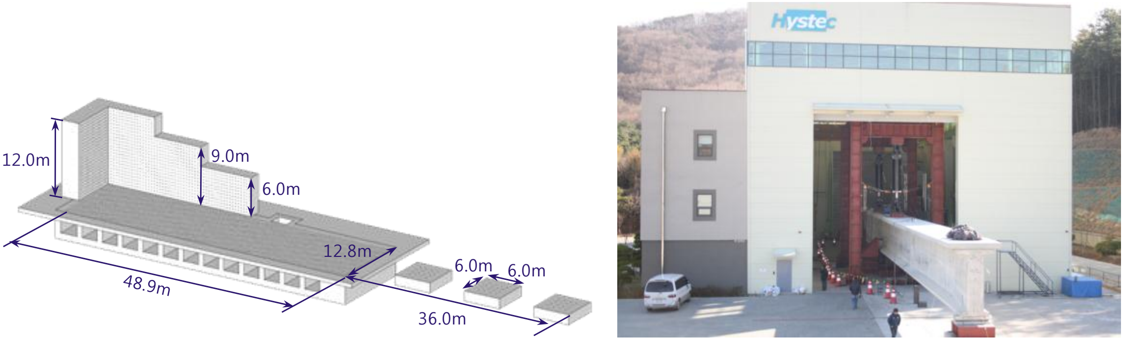

Figure 3. Hybrid Structural Testing Center

2.2 Seismic Simulation Test Center

Unique feature of Seismic Simulation Test Center is multiplatform shaking table system. The system consists of two movable 3-DOF shaking tables and one fixed 6-DOF shaking table as in Figure 4 and they can be excited simultaneously as well as independently. 3-DOF shaking table is made of four actuators and four hydrostatic bearings, making it possible to test a structural model with a maximum weight of 600kN, while 6-DOF shaking table is capable of testing a specimen with a maximum weight of 300kN. Two movable tables can travel up to 20m. Three shaking tables are operated by six hydraulic power supplies that supply 4320 lpm of oil per minute with a pressure of 21MPa which results in actuation frequency between 0.1Hz and 60Hz simultaneously. Four accumulators with a capacity of 35MPa each are installed to provide active operations even in the case the maximum capacity of shaking table is required.

Large hydraulic system of Seismic Simulation Test Center adopts various controlling technologies such as TVC-control and DOF-control to simulate precise vibrations and seismic waves. By using 264ch DAQ system together with optical sensors, it is possible to acquire a large amount of data effectively. Five network cameras are installed in a video conference room as well as in the laboratory section so that remote observation and cooperative research can be provided. This center is hosted by Pusan National University, Pusan.

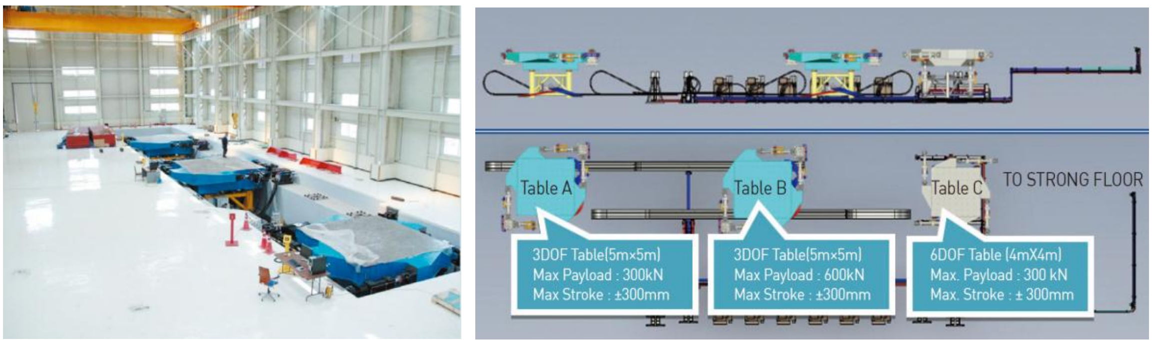

Figure 4. Seismic Simulation Test Center

2.3 Geotechnical Centrifuge Testing Center

In Geotechnical Centrifuge Testing Center, hosted by KAIST, Daejon, scaled model tests of various geotechnical structures can be performed by simulating realistic stress field with high level of centrifugal force. The platform radius of the centrifuge is 5m and it can accelerate the 2400kg payload up to 100g. An advanced 4-DOF in-flight robot and a biaxial shake table system are unique features of this facility. Experimental investigation of behaviour of offshore foundation systems, piled-raft foundation systems, earth dams and ship impact protection systems can be done and also various problems such as soil-foundation-structure interaction, carbon sequestration and gas hydrate problems can be studied using this equipment.

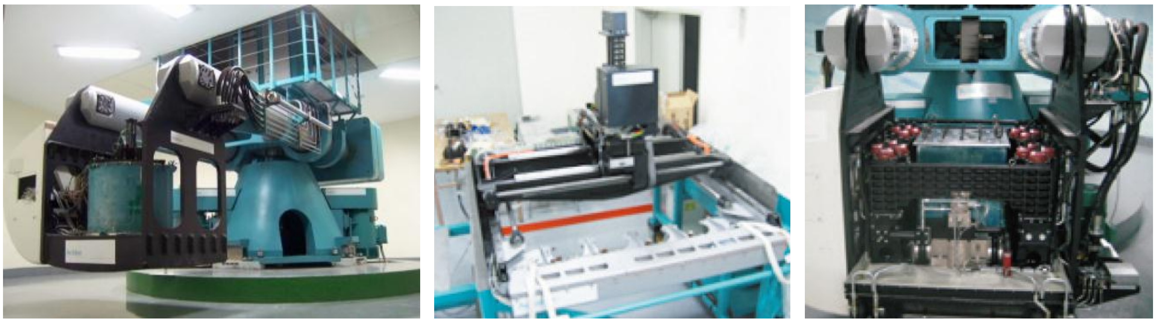

Figure 5. Geotechnical Centrifuge Testing Center

2.4 Advanced Construction Materials Testing Center

This center is composed of six laboratories: concrete and rock test lab; metal and composite materials test lab; structural component test lab; microstructure test lab; long-term behaviour test lab; smart sensor and NDT test lab. And it is equipped with state-of-the-art equipment necessary for performance test of new construction materials and components, such as 5MN universal testing machine, 5MN compression tester, 500kN fatigue tester, 250kN fatigue tester, constant temperature and low temperature control humidity test chambers, creep tester, freezing and thawing apparatus, accelerated neutralization tester, XRD, XRF, porosimeter, automatic vicat tester as well as acoustic emission testing and analysing system. Keimyung University in Daegu hosted this testing facility.

Figure 6. Advanced Construction Materials Testing Center

2.5 Wind Tunnel Center

Wind induced problems at natural atmospheric boundary layer flow such as wind effects on high rise buildings, long span bridges and urban areas as well as various industrial applications can be tested at this testing center. The perspective view of wind tunnel is shown in Figure 7. The wind tunnel has two test sections: the high speed section which is 5m wide, 2.5m high and 20m long, and the low speed section which is 12m wide, 2.5m high, and 40m long. The corresponding maximum wind speeds are 24m/s and 12m/s, respectively. Limited access to control system can be permitted so that remote users can control and monitor tests in real-time through KOCED CI. The facility is located at Chonbuk National University, Chonju.

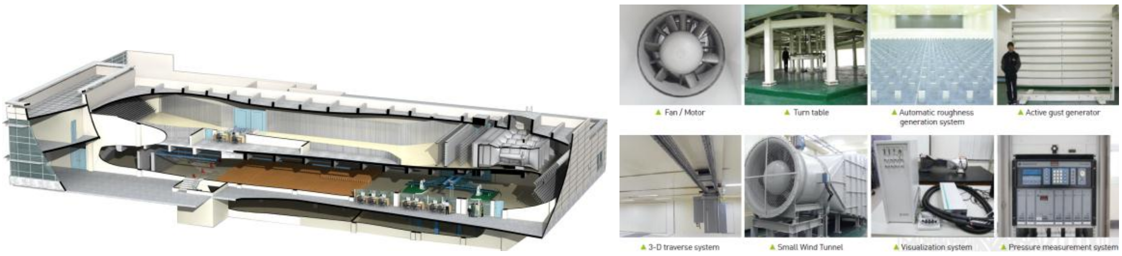

Figure 7. Wind Tunnel Center

2.6 Experimental Center for Coastal & Harbor Engineering

This facility, hosted by Chonnam National University, Yeosu, consists of one 3-D wave basin (50m×50m×1.5m), one 3-D tidal basin (30m×40m×1m), and two 2-D wave flumes (100m×2m×3m, 50m×1m×1.3m). Ocean waves and even tsunami can be precisely simulated so that many ocean and coastal problems can be investigated at this center.

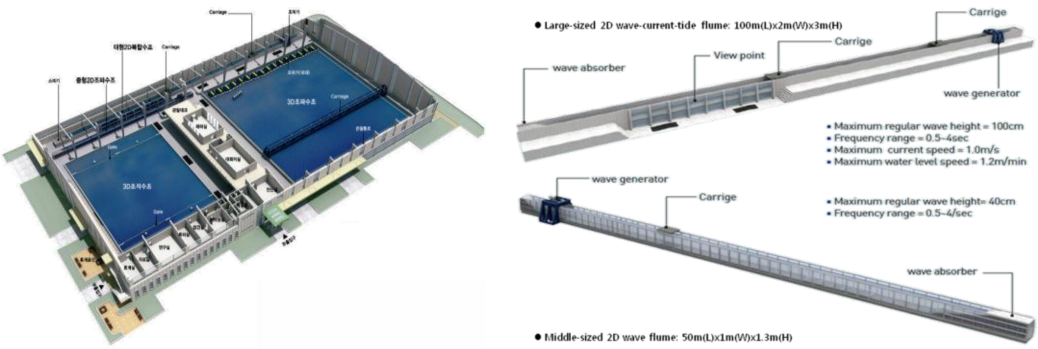

Figure 8. Experimental Center for Coastal & Harbor Engineering

3. PHASE II TESTING FACILITIES (TO BE BUILT)

In the beginning of the KOCED program, 12 testing facilities were originally planned and six of them launched for the first phase on 2004. Since almost 8 years have passed, technical and industrial environment has changed greatly and new research needs arose. Thus research for testing demands was carried out to reflect current research trend and needs, and five testing facilities were selected to be built for the second phase program. In addition to construction of new testing facilities, some testing needs can be covered by installing additional instrument to existing Phase I testing. Thus upgrading of Phase I testing facilities will be carried out separately. Phase II program is planned to be launched on 2013 and finished on 2017.

3.1 Structural Testing Facility for Extreme Events

Recently, construction of mega-size infrastructures such as high-rise buildings and long-span bridges has been increased. These infrastructures are vulnerable to man-made disasters as well as natural disasters and the chance to be exposed to this type of threat is also increasing. Accident at nuclear power plant and terrorism can be typical cases. Thus research activities studying structural behaviour under extreme loads caused by collision, fire and explosion are currently very prominent. This facility will be composed of hydraulic impact testing machine, hydraulic propulsion system and large-caliber high speed impact machine for impact or collision test as well as blast chamber which will bear explosive pressure up to 80MPa.

Figure 9. Structural Testing Facility for Extreme Events

3.2 Large-scale Multi Environmental Testing Facility

In this facility, various climate conditions such as temperature, humidity, wind, solar radiation, rain and snow fall can be artificially produced and controlled in order to evaluate the effect of weather on building structures. This facility should be large enough to investigate overall performance of real size building structures or compartments. Geoprobe-mounted vehicle, power plants to simulate various weather conditions and constant temperature and humidity chambers are included in this facility. And also, it will be equipped with testing instruments such as GC, GC/MS, HPLC, ion chromatography, atomic absorption spectrometer, UV spectrometer, BET analyzer, porosimeter, heat flow & flux meter, ultrasonic wave flow meter, luminance constant meter, illuminometer, pyrheliometer and wind gauge, etc. It is expected to be used in developing environment-friendly construction material, research on energy saving and passive house, evaluating overall performance of buildings as well as certification of construction supplies.

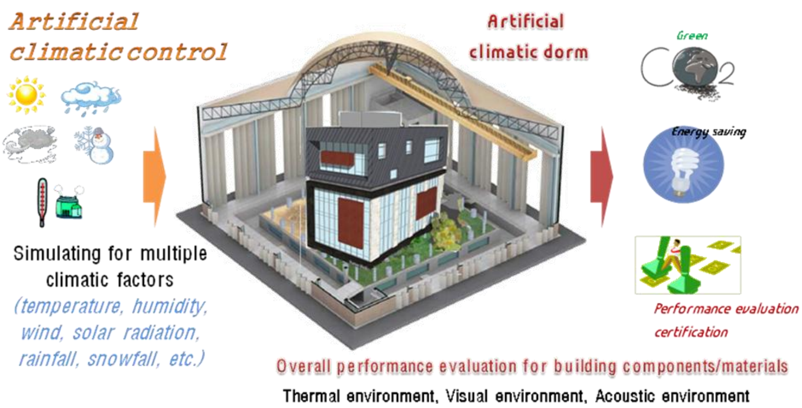

Figure 10. Large-scale Multi Environmental Testing Facility

3.3 Large-scale Hydraulic Model Testing Facility

Recently, national mega-project has been done on four major rivers in Korea to improve the management of water resource and the environment of river basin. Accordingly, the flow of river has been changed and also a large number of structures, such as weirs, floodgates and bridges have been built. Therefore, basic hydraulic research of rivers and streams including the effect of underwater and shore structures becomes very essential. To provide test infrastructure necessary for the above-mentioned research, a large hydraulic model testing facility will have the following facilities: a large indoor hydraulic model test basin at least 150m×100m×10m(L×W×H); variable slope 2-D channel; fixed type open channel; PIV test channel; circulation channel; steep water channel. This facility will be equipped with state-of-the-art instruments such as 1-D propeller current meter, 2-D and 3-D electro-magnetic current meter, ultrasonic and pressure type water level meters, PIV/LDV, etc.

Figure 11. Large-scale Hydraulic Model Test Facility

3.4 Complex Road Safety Testing Facility

This facility will have functions such as simulation of the road condition under extreme weather and performance evaluation of ITS(Intelligent Transportation System), pavement and road safety facility in real-scale. There are several existing road safety testing facilities in Korea, but they have limited functions such as certification test of road safety facility and vehicle collision test. This complex facility will be composed of road safety testing ground, extreme weather testing road, ITS facility and lighting performance testing road, full-scale crash testing ground and control tower. At least 80km/h speed will be available on 1,500m×500m road track.

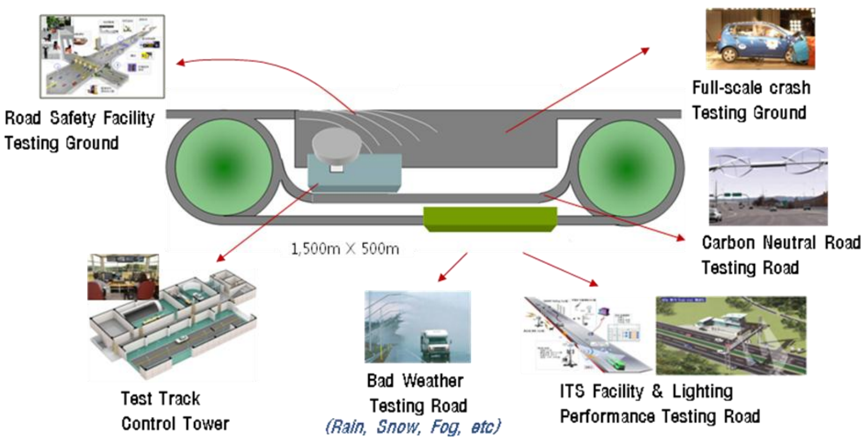

Figure 12. Complex Road Safety Testing Facility

3.5 Vehicle Driving Simulation Facility

This is a virtual simulator of vehicle driving on the road and will be composed of image generation & display system, real-time vehicle simulation system, motion system, cabin & control force loading system, sound system and operating console & monitoring system. This facility can be used in simulation of car accident, design of driver friendly road environment and research of advanced safety vehicle and intelligent transportation system.

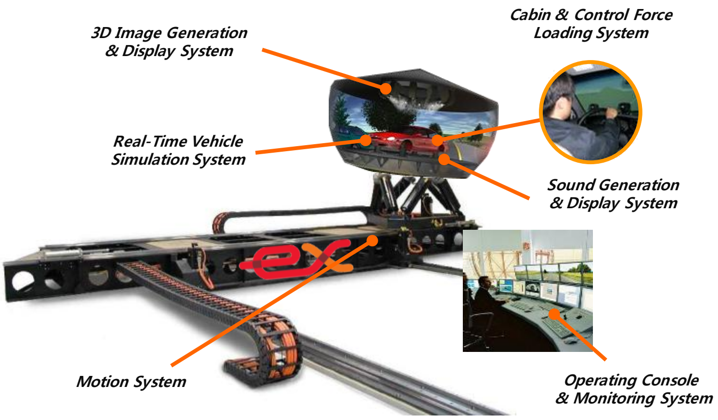

Figure 13. Vehicle Driving Simulation Facility

4. CYBER INFRASTRUCTURE SYSTEM

The KOCED Collaboratory is planned and constructed as distributed testing resources shared and serviced for dispersed users. Therefore, a supporting system not only for research collaboration but also for the management of the facilities is needed. This system which integrates administration function with collaboration function is called as KOCED CI(cyber infrastructure) system. KOCED CI is to provide collaboration services especially to the construction engineering community. A small computing cluster consisting of 40 processors with one master node is chosen to provide visualization function, online hybrid testing and KOCED education grid. All testing facilities and main CI system is linked through high performance information network called KREONET operated by Korea Institute of Science and Technology Information (KISTI).

One of the main objectives of KOCED Collaboratory is to share data, information and knowledge with the relevant research community. To facilitate the dissemination and utilization of experimental data, standardization of test processes and data models were carried out. All of the raw, structured, and processed data will be stored at the central data repository. There are many collaboration services provided by KOCED CI system, and among them tele-presence and webcasting in Figure 14 would be essential ones. A commercial system is adopted for reliable and effective multi-party bidirectional video conference and many convenient functions such as transmitting data, sharing files and electrical board and chatting can be used simultaneously by maximum of 30 participants. On the other hand, webcasting, which is a unidirectional service, does not limit the number of recipients. One strong advantage of the KOCED tele-presence system is that it does not require special equipment other than a web camera per participant. In addition to these core services, small-size test systems are developed for educational purpose since real test systems cannot be controlled remotely due to the safety reason and they are very expensive and hard to operate for small-size tests. Remote users, especially students, can access and operate table-top shake table, miniature centrifuge, wind tunnel and small portable wave basin.

(a) KOCED CI Framework (b) KOCED CI Services

Figure 14. KOCED CI system

5. CONCLUDING REMARKS

Lifting the technology of the civil and construction engineering fields to a higher level by providing a testing infrastructure for research and development is the main objective of the KOCED program. In this article, large testing facilities, six of which were already built in Phase I program and five of which will be built through Phase II program, are briefly introduced. Share of the outcome produced by KOCED facilities will not be limited to Korean research community. KOCED community will be willing to share facilities, information and technology with other researchers in the world to enhance overall construction technology.

Additional information can be found at KOCED portal, www.koced.net.

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