Uniform and Consistent Approach for "Instrument Coding System" Based on Experiences in Iranian Large Arch Dams

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Abstract
Establishment of a uniform and consistent coding system for the instruments in large dams (or other infrastructures) shall be very useful for better understanding of the monitoring results and the dam behavior. Usually, a relatively wide range and different types of instruments are implemented for monitoring the dam and its foundation. Furthermore, sets of the new instruments might be added for different purposes during the reservoir impounding and in operation period. Without a capable coding system, the assigned codes to the instruments will quickly become disorganized, heterogeneous, and confusing.In such conditions, the risk of ambiguities and errors in processing and interpretation of the monitoring results will be increased. Furthermore, controlling of the instrument records and evaluating of their performance will also be difficult. In the common methods, usually only the "type" and "position" of the instrument are considered in coding system.In this paper based on experiences of the coding systems in Karun 3, Seymareh, Khersan 3, and especially Karun 4 arch dam, the developed "uniform and consistent coding system" for dam instruments is presented. This system is capable to assign a uniform code to all the initially designed and later installed instruments with a variable range of key data of the instruments in form of three "code types" which could be used for different purposes. Basic specifications of the instruments like "measurement environment and location", " instrument type", "working mechanism", " manufacturing company" and historical record of each instrument including its "installation date", "specific events", "calibration(s)", "re-installation(s)", "repairs", "replacement", etc. are referred in the proposed coding system.
Keywords: Instrumentation, Coding system, Karun 4, Arch dam, Infrastructure

1. INTRODUCTION

Instrumentation system in a dam project usually includes a relatively wide range and different types of instruments in order to measure and monitor the indicative parameters corresponding to the dam performance and safety. After the impounding and during operation of the dam, instruments are usually calibrated, verified, repaired and replaced, where required. Furthermore, extra instrument might be needed following the actual performance of the dam, and especially in case of occurrenceof any damages to the dam and its foundation, and rehabilitation works.

In monitoring procedure and interpretation of the results, it is very important to consider the history of each instrument including its installation date, specific events, calibration(s), re-installation(s), repairs, replacement, etc. Sometimes, use of scattered and variable methods for instrument coding (in construction stage and during operation for new instruments), will lead to ambiguity and complexity in understanding, processing, and interpretation of the monitoring results.

Definition of a "uniform and consistent coding system" considering all the above issues will effectively improve the accuracy of the processing and interpretation of the monitoring results. The main advantage of such comprehensive approach is providing flexibility and capability for updating the instrument code based on its historical performance and maintenance and assigning the uniform codes to the new installed instruments. In this view, the factors that should be considered in the coding system can be classified as follows [4]:

- Instrument General Features, including:
- Measurement environment and location
- Installation date
- Instrument type
- Measuring mechanism
- Reading method
- Manufacturing company

- History of relocation, re-installation, repair, or replacing of the instrument
- Instrument Special Features, including:
- Installation method
- Status and position of the key elements and/or parameters affecting the instrument performance

In definition of the proposed "Instrument Coding System", experiences and challenges in monitoring of the Karun 4 project are used. In the Karun 4 project, corresponding to the identified important indexes and phenomena affecting the dam behavior, a wide range of instruments had been designed and installed in the dam body, foundation rock mass and critical discontinuities in the dam abutments[1]. Because of early and step-wise impounding of the reservoir, in parallel with completion of the dam construction works, a set of designed instruments are installed during or after impounding and some of them are temporarily installed at the start of impounding and re-installed later on, after completion of the construction works [6].

Furthermore, a considerable set of new temporary and permanent instruments were installed in order to monitor the damages (cracks) caused / observed in the dam after impounding and to control and evaluate the effectiveness of remedial treatments [5]. These somehow complicated situations lead to employing varying types of coding system for the instruments by different parties in different times. Obviously, such scattered coding systems increases the risk of error in understanding, processing, and interpretation of the monitoring results.

In the common methods, usually the type and position of the instrument are considered in coding system. In most of the instruments, like jointmeters, pendulums, clinometers, etc., measuring devices are more sensitive and expensive than the instrument fixed component(s), and usually are not included in the instrument itself. As a common practice, limited number of measuring devices is used for reading of many instruments. Despite the important and affecting function of the measuring devices, no specific codeswere assigned to them in conventional coding systems and recording of their historical performance are not well organized.

The purpose of this paper is to present the developed uniform and consistent instrument coding system, taking into account the all general and specific, and other performance-dependent parameters of instruments. Although the proposed coding system is defined based on instrumentation system of Karun 4 and Karun 3 dams, but the approach is general and could be adjusted and used for other types of dams or infrastructures.

2. INSTRUMENT GENERAL FEATURES

2.1. MEASUREMENT ENVIRONMENT AND LOCATION

The indicative parameters for instrument measuring environment and its installed location could be classified as follows [4]:

- **Dam body**
  - Block number
  - Upstream face
  - Gallery inside the dam – Upstream wall
  - Gallery inside the dam – Downstream wall
  - Adit or chamber in upstream (of gallery) - Left wall (downstream view)
  - Adit or chamber in upstream (of gallery) - Right wall (downstream view)
  - Adit or chamber in downstream (of gallery) - Left wall (downstream view)
  - Adit or chamber in downstream (of gallery) - Right wall (downstream view)
  - Gallery and upstream / downstream adits inside the dam – Floor or Roof
  - Downstream face
  - Along the thickness of the dam (buried instruments)
  - On the outcrop of crack or crossing with the crack plane

- **Dam foundation and abutments**
  - Adjacent dam block number (or left, center, and right abutment)
  - Grouting gallery – Upstream wall (or upstream of the grout curtain)
  - Grouting gallery – Downstream wall (or downstream of the grout curtain)
  - Grouting gallery – Floor or Roof
  - Drainage gallery – Upstream wall (or upstream of the drainage curtain)
  - Drainage gallery – Downstream wall (or downstream of the drainage curtain)

- Drainage gallery – Floor or Roof
- Access galleries or adits – Upstream or Left wall (downstream view)
- Access galleries or adits – Downstream or Right wall (downstream view)
- Access galleries or adits– Floor or Roof
- Free field
- On the outcrop of faults and major joints or crossing with the faults and major joints plane

- **Water**
  - Reservoir surface (adjacent dam block number)
  - Reservoir depth (adjacent dam block number)
  - River

- **Air**
  - In closed spaces inside the dam body (dam block number)
  - Downstream face (dam block number)
  - In the shadow
  - Exposed to the sun

2.2. INSTRUMENT INSTALLATION TIME

- Before start of impounding
- After start of impounding (number of months)

2.3. INSTRUMENT TYPE

- **Pendulum**
  - Direct Pendulum
  - Inverted Pendulum
- Pendulum reading station
- **Extensometer**
  - Single-rod extensometer
  - Multi-rod extensometer

- **Jointmeter**
  - One-dimensional jointmeter
  - Two-dimensional jointmeter
  - Three-dimensional jointmeter

- **Crack-meters**
  - One-dimensional crack-meter
  - Two-dimensional crack-meter
  - Three-dimensional crack-meter

- **Piezometer**
  - Stand Pipe (Casagrande) piezometer
  - Electrical piezometer

- Uplift pressure gauge
- Thermometer
- **Thermocouples**
  - Type T
  - Type K
  - Type PT100

- **DeformeterPins (for cracks or joints)**
  - Two points (one-dimensional) deformeterpins
  - Three points (two-dimensional) deformeterpins
- Strain gauge

- Accelerometer
- Clinometer
- Water Level Indicator
- Observation Well
- Flowmeter (V or U-notch)

2.4. INSTRUMENT WORKING MECHANISM

- Mechanical
- Hydrostatic
- Electrical (current)
- Electrical (resistance)
- Electrical (voltage)
- Vibrating wire (vibration frequency)
- Ultrasonic
- Optical or laser

2.5. INSTRUMENT READING METHOD

- Manual
- Remote or automatic

2.6. INSTRUMENT MANUFACTURING COMPANY

- HUGGENBERGER AG (Switzerland)
- SERAJ ABZAR (Iran)
- SYSCOM (USA)
- ZULLIG (Switzerland)
- SEVIL (UK)
- rittmeyer (Switzerland)
- SOIL INSTRUMENTS (USA)
- Gauge Technic (UK)
- Slope Indicator (USA)

2.7. RECORDS OF INSTRUMENT RELOCATION, REPAIR, AND REPLACEMENT

- Relocation of instrument
- Repair of instrument
- Replacement of instrument

3. INSTRUMENT SPECIFIC FEATURES

Specific features and parameters of each instrument that are somehow affected on the instrument performance and reading, and the nature of the parameter measured by the instrument; are discussed here [4]. These features are included in the instrument coding system.

3.1. Pendulums

- Hanging point elevation (in direct pendulum)
- Suspension or fixed point elevation (in inverted pendulum)
- Reading station (in the proposed coding system due to the importance and effect of the installation position, a separate specific code has been assigned to each pendulum reading stations)

3.2. Extensometers

- Length of the longest rod (or elevation of its endpoint)
- Installation angle to the horizon (slope or dip)

- Installation angle in the horizon relative to the "Y"-axis (toward the downstream) from 0 to 360 degrees clockwise rotating from the + Y origin (dip direction)

3.3. Jointmeters and Crack-meters

- Installation elevation
- Fixed (indicator) jaw on the right (front view)
- Fixed (indicator) jaw on the left (front view)
- Angle of installation relative to the normal alignment to the joint or crack outcrop

3.4. Piezometers

- Elevation of pressure gauge sensor
- Installation angle to the horizon (slope or dip)
- Installation angle in horizon relative to the Y axis (toward downstream) from 0 to 360 degrees rotating clockwise from the + Y origin (dip direction)
- Chainage of instrument location in abutment (foundation) galleries

3.5. Observation Wells

- Well head elevation

3.6. Strain Gauges

- Installation elevation
- Installation angle to the horizon (slope or dip)
- Installation angle in horizon relative to the Y axis (toward downstream) from 0 to 360 degrees rotating clockwise from the + Y origin (dip direction)

3.7. Accelerators

- Installation elevation
- Installation angle to the horizon (slope or dip)
- Installation angle in horizon relative to the Y axis (toward downstream) from 0 to 360 degrees rotating clockwise from the + Y origin (dip direction)

3.8. Clinometers

- Installation elevation
- Installation angle to the horizon (slope or dip)
- Installation angle in horizon relative to the Y axis (toward downstream) from 0 to 360 degrees rotating clockwise from the + Y origin (dip direction)

4. INSTRUMENT CODING CRITERIA

The basic and main features to consider for the proposed instrument coding system can be summarized as follows [4]:

- Comprehensiveness and consistency of the coding system with the aim of recognizing the important and effective parameters of instrument based on the assigned code
- Ability to implement the coding system in ADAS (Automatic Data Acquisition System); usually instrument codes with maximum 16-characters are applicable in the ADAS system, therefore, keeping one character for identifying the measurement components (readings), maximum number of the code characters shall be limited to 15
- Adaptability of the coding system for interactive applications and reporting purposes

Logically,it is not possible to meet all the above requirements in a "single code" of instrument fulfilling the different purposes and objectives. On the other hand, using different coding systems can cause confusion and plurality in the coding system and ultimately violate the basic goals of the instrument coding.Accordingly, in order to adhere to a unique and flexible coding system, the following criteria have been considered in definition of the instrument coding system [4]:

- Use the same number of characters in the coding of all instruments
- Assuring the uniqueness of the assigned code to each instrument
- Ability of the coding system to assign uniform code to all new instruments that shall be installed for any reason in the future
- Flexibility of the coding system to provide appropriate codes for the intended uses keeping the overall framework of instrument code. This could be reached by omitting some of the code characters, remaining the uniqueness property of the code. In this regard, three types of codes are considered:
  - Code Type 1: Comprehensive code of the instrument reflecting all the important and affecting features in its assigned code
  - Code Type 2: Detailed code of the instrument for implementation in ADAS (Automatic Data Acquisition System) or any other similar uses, keeping the main and important features of the instrument
  - Code Type 3: Summarized code of the instrument for interactive and reporting applications remaining the index features and uniqueness of the instrument code

Due to nature of some applied parameters in the instrument code (such as the number of relocations, repairs or replacements, etc.), it shall be needed to update the instrument code accordingly over the time.

In the proposed coding system, following the considerations of different code Types, code Type 1 is defined by 23 characters, code Type 2 is defined by 15 characters (by truncating the last eight characters of the code Type 1), and code Type 3 is defined by 12 characters (by truncating the last three characters of the code Type 2). The proposed coding approach is described in Table 1 and definition of each set of the code characters are explained in tables 2 to 9 [4].Table 10 gives a set of sample codes assigned to various instruments in the proposed coding system [4] [5].

Table 1- Overall concept of the coding system – definition of the three level of instrument codes [4]

Code Type	Working Mechanism [1]	Instrument Type [1]			Measurement Environment and Location				Indicative Parameters of Instrument Position				Reading Method	Installation Time		Instrument Slope [2] (Dip) – (°)		Instrument Angle in Horizon (Dip Direction) (°)			Manufacturing Company		Number of Repairs, …
(Table)	(2)	(3)			(4)				(5)				(6)	(7)		---		---			(8)		(9)
1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	.	.	.	.	.	.	.	.
3	1	2	3	4	5	6	7	8	9	10	11	12	.	.	.	.	.	.	.	.	.	.	.

[1] In the case of the extensometers, the code relating to the working mechanism is omitted, instead of that the instrument type code will have four-letter.

[2] Indicator alignment to determine the slope (dip) and dip direction of the three-points pin is the line drawn from middle of the line connecting the two points locating on one side to the point locates on the opposite side of the crack (or joint).

[2] The index alignment for slope (dip) and dip direction in the V or U-Notch instruments is the flow direction.

Table 2- Codes corresponding to instrument working mechanism [4]

Instrument Working Mechanism	Code
Mechanical	M
Hydrostatic or Stand Pipe	S
Electrical (current)	E
Electrical (resistance)	
Electrical (voltage)	
Vibrating Wire	V
Ultra-Sonic	U
Optical or Laser	O

Table 3- Codes corresponding to instrument type [4]

Instrument Type	Code
Direct Pendulum	DP-
Invert Pendulum	IP-
Direct Pendulum Reading Station	DPS
Invert Pendulum Reading Station	IPS
Pendulum Reading Device - Cardioscope	PRD
Extensometer	EXnn
Extensometer Reading Device	EXRD
Jointmeter – Indicator Jaw in Left	JML
Jointmeter – Indicator Jaw in Right	JMR
Crack-meter – Indicator Jaw in Left	CML
Crack-meter – Indicator Jaw in Right	CMR
Jointmeter Reading Device	JRD
Piezometer	PZ-
Uplift-meter	UP-
Thermometer	TM-
Thermocouple – Type T	TCT
Thermocouple – Type K	TCK
Thermocouple – Type PT100	TCP
Thermometer Reading Device	TRD
2-Point Pin Deformeter	PN2
3-Point Pin Deformeter	PN3
Pin Deformeter Reading Device	DRD
Strain Gauge	SG-
Strong Motion Recorder	SMR
Clinometer	CL-
Clinometer Reading Device	CRD
Water Level Indicator	WLI
Observation Well	OBW
Observation Well Reading Device	ORD
V/U-notch Flow Meter	VN- / UN-
V/U-notch Reading Device	NRD

Table 4- Codes corresponding to measurement environment and location [4]

Measurement environment and location		Code
Dam Body [1]	Non-buried Instruments (in dam galleries and shafts or on dam faces)	1□ □ □
	Buried Instruments in the dam concrete	2□ □ □
	Instruments on the dam cracks (in each dam block, cracks shall be numbered from 3 to 8 in order of their observation)	(3~8)□ □ □
	Dam block number	□nn□
Non-buried Instruments	Upstream face	□ □1□
	Gallery inside the dam – Upstream wall	□ □2□
	Gallery inside the dam – Downstream wall	□ □3□
	Adit or chamber in upstream (of gallery) - Left wall (downstream view)	□ □4□
	Adit or chamber in upstream (of gallery) - Right wall (downstream view)	□ □5□
	Adit or chamber in downstream (of gallery) - Left wall (downstream view)	□ □6□
	Adit or chamber in downstream (of gallery) - Right wall (downstream view)	□ □7□
	Gallery and upstream and downstream adits inside the dam – Floor/Roof	□ □8□
	Downstream face	□ □9□
Buried Instruments	Along the thickness of the dam (buried instruments)	□ □(1□~9)
Dam Foundation and Abutments	Left bank	L□ □ □
	Right bank	R□ □ □
	Central foundation	□0□ □
	Faults & major joints (numbering of instruments based on importance and installation time)	□(1~9)□ □
	Grouting gallery (galleries numbered from top to down)	□ □(1-n)□
	Drainage gallery (galleries numbered from top to down)	□ □(n-9)□

Measurement environment and location		Code
	Free field	? ?0
	Rock surface (outcrops of faults, major joints, etc.)	? ?0?
	Grouting or drainage gallery – Upstream wall	? ?1?
	Grouting or drainage gallery – Downstream wall	? ?2?
	Grouting or drainage gallery – Floor or Roof	? ?3?
	Adits& galleries parallel to grout curtain - Upstream wall	? ?4?
	Adits& galleries parallel to grout curtain - Downstream wall	? ?5?
	Adits& galleries parallel to grout curtain - Floor or Roof	? ?6?
	Adits& galleries perpendicular to grout curtain - Left wall (D/S view)	? ?7?
	Adits& galleries perpendicular to grout curtain - Right wall (D/S view)	? ?8?
	Adits& galleries perpendicular to grout curtain – Floor or Roof	? ?9?
Water	River	91? ?
	Reservoir	92? ?
	River (nn: No. of similar instrument from U/S to D/S)	? ?n
	Reservoir surface (n: No. of similar instrument from left to right)	? ?0
	Reservoir depth (n: No. of similar instrument from left to right) and (m: No. of similar instrument from top to down)	? ?m
Air	Dam downstream face	95? ?
	Closed spaces inside the dam body	96? ?
	Open air	97? ?
	Dam block number (nn) - downstream face or closed spaces inside the dam body	? ?n
	Shadow (n: No. of similar instrument from U/S to D/S & left to right)	? 8n
	Exposed to sun (n: No. of similar instrument from U/S to D/S & left to right)	? 9n

[1] *The reference dam block number for jointmeters is the one on which the indicator (or reference) jaw is installed).*

Table 5- Codes corresponding to indicative parameters of instrument position [4]

Instrument Type	Code	
Direct Pendulum	Elevation of wire hanging point	nnnn
Inverted Pendulum	Elevation of wire fix point	nnnn
Pendulum Reading Station	Elevation of reading station	nnnn
Extensometer	Elevation of extensometer head	nnnn
Jointmeter& crack-meter	Elevation of instrument installation	nnnn
Piezometer	Elevation of pressure sensor	nnnn
Thermometer & thermocouple	Elevation of instrument installation	nnnn
Deformeter Pins	Elevation of instrument installation	nnnn
Strain Gauge	Elevation of instrument installation	nnnn
Accelerometer	Elevation of instrument installation	nnnn
Clinometer	Elevation of instrument installation	nnnn
Water level indicator	Elevation of instrument installation	nnnn
Observation Well	Well head elevation	nnnn
Flow-meter (V or U notch)	Elevation of instrument installation	nnnn
Measuring Devices	Indicative number of measuring device	00mm

Table 6- Codes corresponding to reading method [4]

Reading Method	Code
Manual	M
Remote or Automatic	R

Table 7- Codes corresponding to instrument installation time [4]

instrument installation time	Code
Before start of impounding	00
After start of impounding (No. of months)	01 ~ 99

Table 8- Codes corresponding to instrument manufacturer [4]

Instrument manufacturer company	Code
HUGENBERGER (Switzerland)	**HB**
SERAJ ABZAR (Iran)	**SA**
SYSCOM (USA)	**SY**
ZULLIG (Switzerland)	**ZU**
SEVIL (UK)	**SE**
rittmeyer (Switzerland)	**RI**
SOIL INSTRUMENTS (USA)	**SI**
GAUGE TECHNIC (UK)	**GT**
SLOPE INDICATOR (USA)	**SL**

Table 9- Codes corresponding to No. of relocations, repairs, replacement, etc. [4]

Records of No. of Instrument Relocations, Repairs, Replacement, etc.	Code
Instrument relocation	The total times the instrument is relocated, repaired, or replaced
Instrument repair	
Instrument replacement	

Table 10- Sample codes assigned to various instruments types in the proposed coding system [4] [5]

Instrument	Working Mechanism	Instrument Type			Measurement Environment and Location				Indicative Parameters of Instrument Position				Reading Method	Installation Time		Instrument Slope (Dip) – (°)		Instrument Angle in Horizon (Dip Direction) - (°)			Manufacturing Company		Number of Repairs, …
Direct Pendulum	M	D	P	-	1	0	9	8	1	0	1	6	M	0	0	9	0	0	0	0	H	B	0
InvertedPendulum	M	I	P	-	1	0	9	8	0	8	9	0	M	0	0	9	0	0	0	0	H	B	0
Pendulum Reading Station	M	D	P	S	1	0	9	4	0	9	9	8	M	0	0	0	0	0	0	5	H	B	0
	M	I	P	S	1	0	9	5	0	8	9	0	M	0	0	0	0	0	0	3	H	B	0
Pendulum Reading Device	O	P	R	D	1	0	9	4	0	9	9	8	R	5	3	0	0	0	0	5	H	B	0
Extensometer & its Reading Device	E	X	5	4	L	0	9	1	0	8	9	0	M	0	0	6	0	2	4	5	H	B	2
	E	X	R	D	0	0	0	0	0	0	0	1	M	0	0	0	0	0	0	0	H	B	0
Jointmeter	M	J	M	L	1	1	6	2	1	0	1	6	M	0	6	0	5	0	7	2	S	A	0
Crack-meter	M	C	M	R	1	0	9	2	0	9	1	1	M	4	9	0	8	2	5	0	S	A	1
Jointmeter Reading Device	M	J	R	D	0	0	0	0	0	0	0	2	M	0	0	0	0	0	0	0	S	A	1
Piezometer	S	P	Z	-	L	0	4	1	0	9	3	2	M	0	0	6	5	2	3	6	H	B	0
Uplift Gauge	S	U	P	-	2	0	1	8	0	8	0	6	M	7	3	0	0	0	0	0	H	B	0
Thermometer	E	T	M	-	2	1	0	5	0	9	9	7	M	0	0	0	0	0	0	0	H	B	0
Thermocouple	E	T	C	T	2	1	0	6	1	0	1	4	M	0	0	0	0	0	0	0	H	B	0
Thermometer Reading Device	E	T	R	D	0	0	0	0	0	0	0	1	M	0	0	0	0	0	0	0	H	B	0
Deformeter Pin	M	P	N	3	1	0	9	9	0	8	9	3	M	0	0	0	8	2	2	9	S	A	0
Pin Reading Device	M	D	R	D	0	0	0	0	0	0	0	2	M	0	0	0	0	0	0	0	S	A	0
Strain Gauge	E	S	G	-	2	0	0	4	0	9	9	6	M	0	0	0	6	0	1	0	S	A	0
Accelerometer	M	S	M	R	1	0	0	8	0	9	9	8	M	0	0	0	0	0	8	5	S	Y	1
Clinometer	M	C	L	-	1	2	0	3	1	0	1	6	M	0	0	9	0	0	0	6	H	B	0
Clinometer Reading Device	M	C	R	D	0	0	0	0	0	0	0	2	M	0	0	0	0	0	0	0	H	B	1
Water Level Indicator	E	W	L	I	1	0	0	1	0	9	3	3	R	0	0	0	0	0	0	0	R	I	0
Observation Well	S	O	B	W	L	0	0	0	1	0	3	5	M	0	0	9	0	0	0	0	-	-	0
Observation Well Reading Device	S	O	R	D	0	0	0	0	0	0	0	1	M	0	0	0	0	0	0	0	X	X	0
V-notch flow-meter	S	V	N	-	1	0	9	8	0	8	9	0	M	0	0	0	5	2	4	6	X	X	0
Flow-meter Reading Device	U	N	R	D	0	0	0	0	0	0	0	1	M	0	0	0	0	0	0	0	X	X	0

5. CONCLUSIONS

Establishment of a uniform and consistent coding system for the instruments in large dams (or other infrastructures) is an essential requirement for providing a reasonable basis for monitoring, understanding, and interpretation of the dam behavior. The common "instrument coding systems" are usually developed for the initially designed instrumentation system considering the "type" and "position" of the instruments [1] [2] [3]. Usually, sets of the new instruments will be installed in the dam and its foundation during operation for different purposes, especially where damages occur and for control and assessing the rehabilitation works. In such cases, scattered and inconsistent instrument coding system will be implemented by different related parties. As the result, the assigned codes to the instruments will quickly become disorganized, heterogeneous, and confusing. Experiences in Karun 4 project well explain the inconsistency in coding system of the instrument (Table 11) [4].

Table 11- Inconsistency and scattered approach in instrument coding system in Karun 4 project

Instrument	Previous Code	New Assigned Code		
		Type 3	Type 2	Type 1
Foundation Extensometers *(basic design)*	EX54-6-848-3	EX54R0520848	EX54R0520848M00	EX54R0520848M0050245HB0
	EX54-8-869-3	EX54R0420869	EX54R0420869M00	EX54R0420869M0042246HB0
	EX42-13-953-2	EX42L0230953	EX42L0230953M00	EX42L0230953M0030162HB0
Crack Extensometers *(later installed)*	EX-0-806-55	EX15L0510806	EX15L0510806M78	EX15L0510806M7805039HB0
	EX827-B1-A	EX1920120827	EX1920120827M79	EX1920120827M7950052SA0
	EX-827-B1-B	EX1920120827	EX1920120827M79	EX1920120827M7942074SA0
Electrical Piezometers *(basic design)*	EP-17-974-1	VPZ-L0210972	VPZ-L0210972M00	VPZ-L0210972M0017075SE0
	EP-11-890-1	VPZ-L0410889	VPZ-L0410889M00	VPZ-L0410889M0011075SE0
	EP-05-827- 2L	VPZ-L0530775	VPZ-L0530775M00	VPZ-L0530775M0078070SE0
Casagrande Piezometers *(basic design)*	SP-RG3-50/1	SPZ-R0310910	SPZ-R0310910M00	SPZ-R0310910M0036024HB0
	SP-LDG1-113/3	SPZ-L0150910	SPZ-L0150910M00	SPZ-L0150910M0025256HB0
	SPLDG2-111.5/3	SPZ-L0250817	SPZ-L0250817M04	SPZ-L0250817M0420255HB0
Thermometers *(basic design)*	890-TA	ETM-21030901	ETM-21030901M00	ETM-21030901M0000000HB0
	974-TW	ETM-20020986	ETM-20020986M00	ETM-20020986M0000000HB0
	848-TA5	ETM-20020859	ETM-20020859M00	ETM-20020859M0000000HB0

In such conditions, the risk of ambiguities and errors in processing, understanding, and interpretation of the monitoring results will be increased. Furthermore, controlling of the instrument records and evaluating of their performance will also be difficult.

In the proposed approach, where mainly developed for Karun 4 project a "uniform","consistent", and "unique" code is defined and assigned for each instrument. This system is capable to assign a similar and uniform code to all new and extra instruments that might be installed after reservoir impounding.Basic specifications of the instruments like "measurement environment and location", " instrument type", "working mechanism", " manufacturing company" and historical record of each instrument including its "installation date", "specific events", "calibration(s)", "re-installation(s)", "repairs", "replacement", etc. are referred in the proposed coding system.

In the developed coding system, in order to adapt with different uses, the assigned code could be shrinked and summarized keeping the required key and essential features of the code. Accordingly, three "code types" are defined as described in this paper. Samples of the new assigned codes comparing with the previous one are indicated in table 11 [4].

6. REFERENCES

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