STUDIUL PROPRIETĂȚILOR MECANICE ALE BETONULUI AUTOCOMPACTANT PREPARAT CU NISIP DE DUNĂ
A STUDY ON MECHANICAL PROPERTIES OF SELF-COMPACTING CONCRETE MADE UTILIZING GROUND DUNE SAND

FARID BENMERIOUL[1], AHMED TAFRAOUI[2], ABDELKADIR MAKANI[2]*, SAID ZAOUAI[1]
[1]*Laboratoire de Fiabilité des Matériaux et des Structures (FIMAS), Université Tahri Mohammed – Béchar, BP. 417 - Béchar (08000), Algeria*
[2]*Laboratoire de Fiabilité du Génie Mécanique (LFGM), Université Tahri Mohammed Béchar, BP. 417 Béchar (08000), Algeria*

The manufacture of Portland cement process is often related to a high consumption of energy and resources. In this manner, there is a need to supplant the Portland cement with more ecological and friendly materials. This paper introduces the outcome of experimental work on short and long-term mechanical properties of self-compacting concrete which contain different levels of ground dune sand (GDS). The purpose of the study is to investigate the effects of binder systems containing different levels of ground dune sand on fresh and mechanical properties of concrete. The work concentrated on cement blends having an altered water/folio proportion of 0.5 and a consistent total binder content of 520 kg/m^3. The ground dune sand percentages that replaced cement in this research were: 0%, 10%, 15% and 20%. Aside from measuring the workability of fresh concrete, the mechanical properties evaluated were: development of compressive strength and shrinkage. The aftereffects of this exploration demonstrate that the proportion of ground dune sand increased, by the decreasing of workability of concrete; however, we noticed an improvement of its mechanical properties short-term such as 28-day compressive strength. Moreover, the total shrinkage of concrete decreased at higher ground dune sand replacement levels.

Keywords: *Self-compacting concrete, Ground dune sand, Compressive strength, Shrinkage*

1. Introduction

Sand dune (SD) is a natural abundant material which never seriously used in constructions, the Algerian desert contains inexhaustible quantities of dune sand, and indeed the dune sand of western erg has occupied 6% of the desert surface. According to chemical properties it has high content of quartz silica [1]. Therefore, it has been used as partial replacement sand for fine aggregate and backfilling materials only [2]. A very limited work has been carried out to study the possibility of using dune sand as cement replacement materials [3].

At the end of the 20th century, a new era of concrete was produced: self-compacting concretes (SCC) [4]. These (SCC) make a new technological step in civil engineering, it is very fluid concrete whose putting in place without vibration, it has several advantages so much at the environmental ,technological and economic level which interests the industrialists more and more [5]. It is essential that the concrete retains its stability and ensures perfect homogeneity. These two contradictory properties are provided by the use of superplasticizers and the incorporation of the mineral additions in their compositions [6].

The prediction of short and long-term time-dependent deformations, free shrinkage or creep deformations has a great importance in civil engineering design since they affect deflection, loss of pre-stressing force in cables and normal stress distribution in statically indeterminate structures.
However, the influence of some parameters on the long term mechanical behavior remains fully unknown [7]. The aggregates and mineral additions were considered as a part of the characteristic parameters of the concrete because of their direct effect on the mechanical behavior and durability of structures [8]. However, the influences of some parameters are not taken into account in the current prediction models which might cause inaccuracies in their predictions.

Five models for predicting the delayed behaviors (shrinkage and creep) of the concretes are presented in Table 1: two European models Euro code 2: (the version intended for the structures which taking into account the delayed deformations is paramount) [9 – 11], B3 model [12] and GL2000 model [13]. The ACI 209 model is the oldest of these models but it is still used today in the United States. Comparative studies of physical and theoretical basis of some of these models are proposed in the literature [14]. The main parameters required

* Autor corespondent/*Corresponding author*,
E-mail: makaniabdelkadir@yahoo.fr

Table 1

Parameters of concrete composition and environmental conditions required for each studied model

Parameters		Model				
		EC2	ACI-209	CEB-FIP	B3	GL2000
Intrinsic Factors	Cement type	X	X	X	X	X
	Cement content	-	-	-	X	-
	Aggregates type	-	-	X	-	-
	Aggregates percentage	-	-	-	X	-
	Concrete Density	-	X	-	-	-
	Water or air content	-	-	-	X	-
	Mineral addition	X	-	-	-	-
	Compressive strength	X	X	X	X	X
	Modulus of elasticity	X	X	X	X	X
Extrinsic Factors	Age of curing	X	X	X	X	X
	Curing Conditions	-	X	-	X	-
	Relative humidity	X	X	X	X	X
	Specimen size	X	X	X	X	X

for each model are listed in Table1. Although many parameters are considered in these models; it seems that other factors could also have a considerable effect (for example and in the optics of our study, the influence of mineral addition).

The outcome of this study is expected to encourage the use of ground dune sand (GDS) as a cement replacement material in self-compacting concrete. This research aimed to elicit the result of a study that investigated the affect of binder systems containing different levels of the finely crushed dune sand on the rheological at the fresh state, mechanical strength and free shrinkage of SCC which its experimental results have been compared with prediction models.

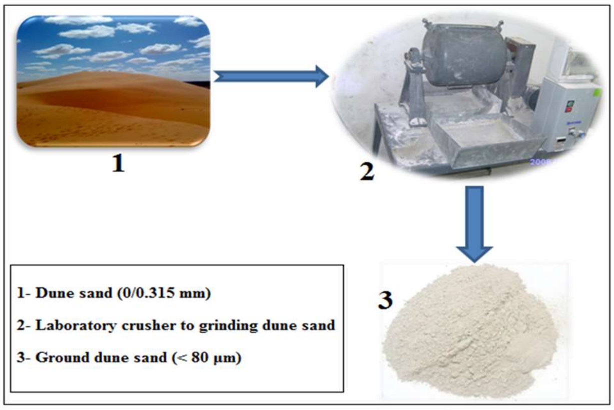


Fig. 1 - Process for production of Ground Dune Sand (GDS).

2. Materials and experimental procedures

2.1. Characterization of basic materials

The used cement is composed Portland cement CEM II / B resistance real 42.5 MPa. Ground dune sand coming from crushing dune sand (Fig 1) which is found at Taghit, of Bechar (Algeria), the maximum coarse aggregate of GDS does not exceed 80 µm. Sand rolled of class (0/3mm), (3/8 mm, 8/15 mm) were used in the formulation of concrete. The superplastifiant SIKAPLAST 5045 / high reductive self-timer of water / for ready to use concrete and SCC are compliant with NF en 934-2.

The chemical compositions of cement and crushed sand of dunes are presented in Table 2. The physical characteristics of the additions and the aggregates are recorded respectively in Tables 3 and 4. It may be noted that crushed dune sand contains a proportion in silica, as well as the

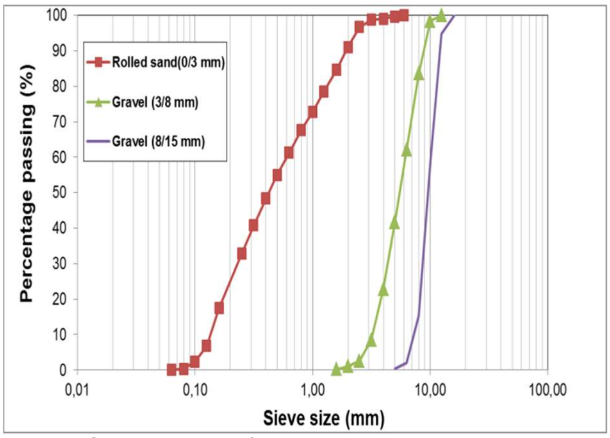


Fig. 2 - Grading curves of aggregates.

presence of certain elements, namely magnesium, aluminium, potassium, calcium, iron and titanium. GDS is a finer addition characterized by a Blaine surface of 3000 cm^2/g. The particle size distribution of the aggregates used is presented in Figure 2.

Table 2

Chemical Properties of cement and ground dune sand

Elements (%)	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	TiO_2	Others	Loss of ignition (%)
Cement	17.49	4.51	3.02	62.78	2.15	2.38	0.05	0.64	0.02	8.10
GDS	97.15	0.79	0.21	0.11	0.05	0.14	0.18	0.05	< 0,02	0.58

Table 3

Physical properties of cement and ground dune sand.

Items	Cement	GDS	Regulatory
Specific density	3.05	2.80	NF P 18-558
specific surface cm^2/g	3200	3000	EN 196-6
Unit weight (kg/m^3)	1120	1300	NF P 18-554

Table 4

Physical properties of aggregates

Items	Sand rolled (0/3)	Gravel. (3/8)	Gravel. (8/15)	Regulatory
Specific density	2.66	2.50	2.70	NF P 18-554
Fineness modulus	2.13	—	—	NF P 18-560
Sand equivalency (%)	87	—	—	NF P 18-598
Unit weight (kg/m3)	1450	1380	1440	NF P 18-554

Table 5

Mix proportion of Self-compacting mixes (kg/m^3)

Mix proportion	SCC 0% GSD	SCC 10% GSD	SCC 15% GDS	SCC 20% GDS
Cement	520	473	442	416
Ground dune sand	–	52	78	104
Sand (0/3)	900			
Gravel (3/8)	150			
Gravel (8/15)	580			
Superplasticizer	8.2			
Water / Binder	0.50			

2.2. Experimental methods

2.2.1. Mix procedure for SCC

To this effect, we initially formulated SCC by using only the criteria recommended by [15]. The final formulation SCC is given in Table 5. The sequence of mixing was as follows:

- Mixing during 30s of the dry components (aggregates, fine and cement).
- Introduction of mixing water with part of the adjuvant and to continue mixing during 1 min 30 s.
- Introduction of the remaining part of the additives and mixing during 2 min.

In this study, the dune sand ground is used as a mineral addition has been prepared and examined to quantify the properties of SCC with concrete cement partially replaced by sand dune crushed (0%, 10%, 15%, 20%).The mixtures having a fixed water / binder of 0.5 ratio and a constant total amount of binder of 520 kg/m^3. Some design guidelines have been prepared from the acceptable test methods [16] no single method has been found which characterizes all the relevant workability aspects so each mix design should be tested by more than one test method in order to obtain different workability parameters .

a- Slump flow b- L-Box c- Stability in sieve

Fig. 3 - Qualification test of self-compactability concrete

Table 6

Fresh properties of self- compacting mixes

SCC mixes	Fresh properties			
	Slump flow (cm)	L-box	T_{50} (s)	Segregation index (%)
SCC 0% GSD	73	0.88	2.18	10
SCC 10% GSD	73	0.9	2.18	7.1
SCC 15% GDS	74	0.83	2.5	14
SCC 20% GDS	70	0.88	2.01	10.7
Limited values according to [AFGC, 2008].	60 - 75	≥ 0.80	-	≤ 15

2.2.2. Tests on fresh SCC

At the end of mixing, tests on fresh properties of SCC was conducted, including slump flow, L-box test, and sieve stability test respectively to characterize the behavior in a fresh state of the concretes and to check their designation as self-compacting concrete with respecting the recommendations AFGC [15].

Maximum deformability of concrete in the absence of obstacles has been evaluated by the spreading test that considers the ability of the concrete to deform under its own weight against the friction of the surface without external constraint this; It is a cone has been filled with concrete without compaction. The spreading value given by measuring the average of the two diameters of the wafer to two perpendicular directions of the concrete after removal of the Abrams cone and the concrete stops flowing .The L-box test is used to evaluate the fluidity of SCC and the ability for SCC to pass through steel bars. The L-box consists of a ‘‘chimney” section and a ‘‘channel” section [17], According to [15], when the filling ratio is greater than 0.8, the SCC having a good ability to pass.

Segregation resistance ability of SCC was evaluated by sieve segregation test [EN12350-11]. Segregation index was the percentage of laitance passing through 5 mm sieve to the total weight of the sample.

2.2.3. Tests on hardened SCC

The samples were subsequently cast without vibration all from the same batch by scoops intended for the tests of compressive strength according to norm NF18-406., and measure the shrinkage according to norm NF18-433.

After about 24 h, all specimens for compressive strength test were de-molded, marked and cured in the water at 21 °C until the date of testing, while the shrinkage specimens were aired. The measurements of shrinkage were recorded from 24 h after the casting, all testing was completed on three samples and the average value reported

3. Results and discussion

3.1. Workability of fresh concrete

To better assets the workability of SCC, both dynamic and static stability tests are usually required [18]. Dynamic steadiness is concerned with the properties of SCC during the blending process, transportation, and casting, while static stability deals with the properties of SCC during the period from casting to initial set [17].

In Table 6 it was observed that all the self-compacting concretes (SCC) respect the criteria recommended for testing [15]. For all SCC, the aureole milt at the periphery of concrete patties was absent or very low (1 to 2 mm). In addition, large aggregates have always been trained properly by the cementitious matrix and did not remain piled in the middle of the slabs of concrete.

The values of the spread for the SCC with crushed sand dune, immediately after the mixing process, are presented in Table 6.It ranges between 70 and 74 cm, which authorizes their qualification of self-compactability concrete according to recommendations of the AFGC [15].The differences between these values are relatively low and do not identify any influence of the type of mineral additives on behavior in the fresh state.

For the dynamic segregation of SCC, the L-box test is more sensitive to blocking. There is a risk of blocking of the mixture when the L-box blocking ratio is below 0.8.If the concrete flows as freely as water, at rest it will be horizontal, so $H_2/H_1 = 1$. Therefore the nearer this test value, the "blocking ratio", is to unity, the better the flow of the concrete. The increase effect in the volume of coarse aggregate on the L-Box test indicated a significant decrease of the blocking ratio. The results shown by the Table 6 are conforming to what can be expected of a self-compacting concrete. However, the most important in this assay is that the concrete flows through test frames correctly. On this point, no problems to report since all the SCC present rate higher than 0.80. The rate of filling decreases (15%) and rises to 20%.

The Time measured to reach a ring 50 cm in diameter (T_{50}) for concrete is between 2 and 2.5 seconds. This value is close to the values usually recorded in the bibliography, indeed, [15] suggests that this value is 2 to 5 seconds.

For the static segregation, the sieve stability is used to study the resistance to segregation and bleeding of SCC, which must be stable under the effect of gravity. This test shows that there is no risk of segregation, all the compositions tested have a satisfactory stability (0% < p < 15%).

3.2. Compressive strength

The compressive strength is an indicative feature of concrete which allows us to consider other properties. Generally, enhanced durability properties can be obtained with concretes of higher compressive strength [19]. The Figure 3a presents the compressive strength of various SCC mixes determined at different ages. As expected, the compressive strength of SCC increased with age. As can be observed, the compressive strength slightly increased with increase of amount of ground dune sand. This is due to the physical nature of better packing, as addition of GDS governs the compressive strength due to the denser matrix and the better dispersion of cement grains [20]. Furthermore, the microstructure analyses reveal how GDS contributes to the strength and physical properties of concrete, the XRD, DTA and TGA results indicated that the quartz silica of GDS reacted with CH to form additional CSH. The SEM and EDX results showed the clear formation of dense and newly formed thin crystalline calcium silicate hydrate with a low CaO/SiO_2 ratio [21]. Fineness of the GDS also affects the strength as it filled up the micro pores within the concrete matrix [22] and densified the concrete. The GDS have improved the properties of SCC such as porosity reduced and better bonding in inter transition zone.

These results can be explained according to [23, 24]. That the ground dune sand activity resulted principally from three effects: physical, physico-chemical and chemical. These effects act simultaneously and in a complementary way on the compressive strengths of concrete.

Physical effect: an improvement of the compressive strengths by a thickening of the SCC pastes.

Physico-chemical effect: a physical process produces a chemical activation of cement hydration and depends on the content and fineness of the ground dune sand, which acts on the evolution of the compressive strengths at early-age. The presence of GDS accelerates the reaction of cement hydration. This accelerating effect of GDS on the hydration combined with the physical effect, due to their fineness, can lead to better short term compressive strengths.

Chemical effect: lime provided in the case of Portland cement and consumed by the pozzolanic reaction, caused by the addition of GDS to cement, it improved the compressive strengths of SCC pastes at average and especially at long-term.

The Figure.4b presents the evolution of compressive strength with different percentage of ground dune sand of self-compacting concrete, good relationship exists between compressive strength and ground dune sand percentage for various mixtures of self-compacting concrete which can be inferred from Figure.4b.

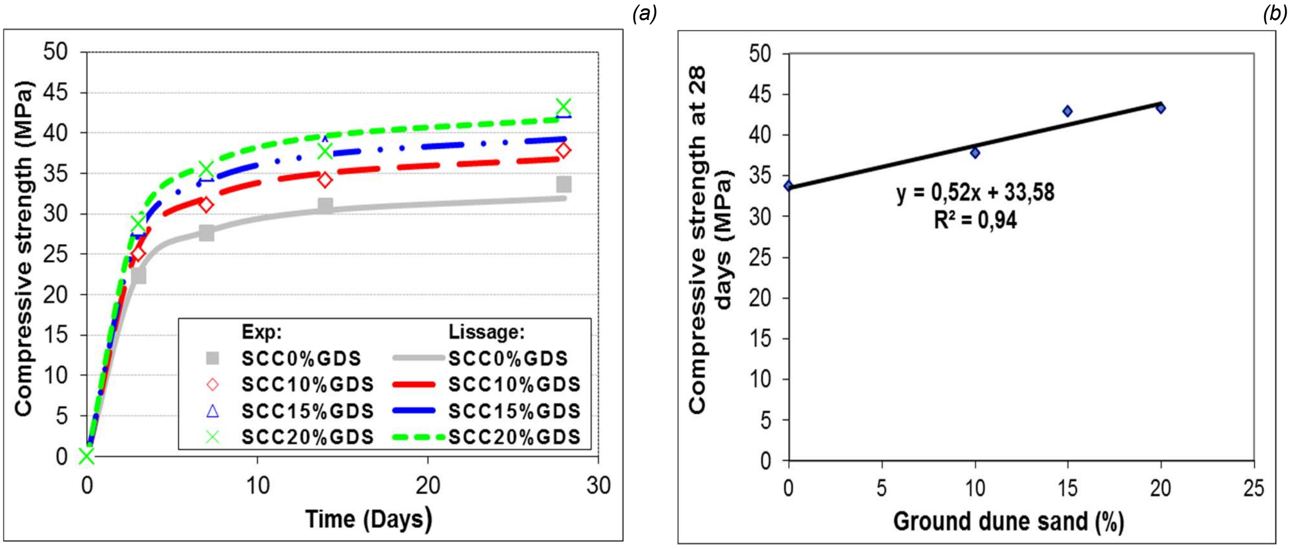
R^2= 0.94.

R^2 = A number that reveals how closely the estimated values of equations corresponds to actual data. The compliance of above equation is justified since they were found to have $R^2 = 1$.

3.3. Shrinkage

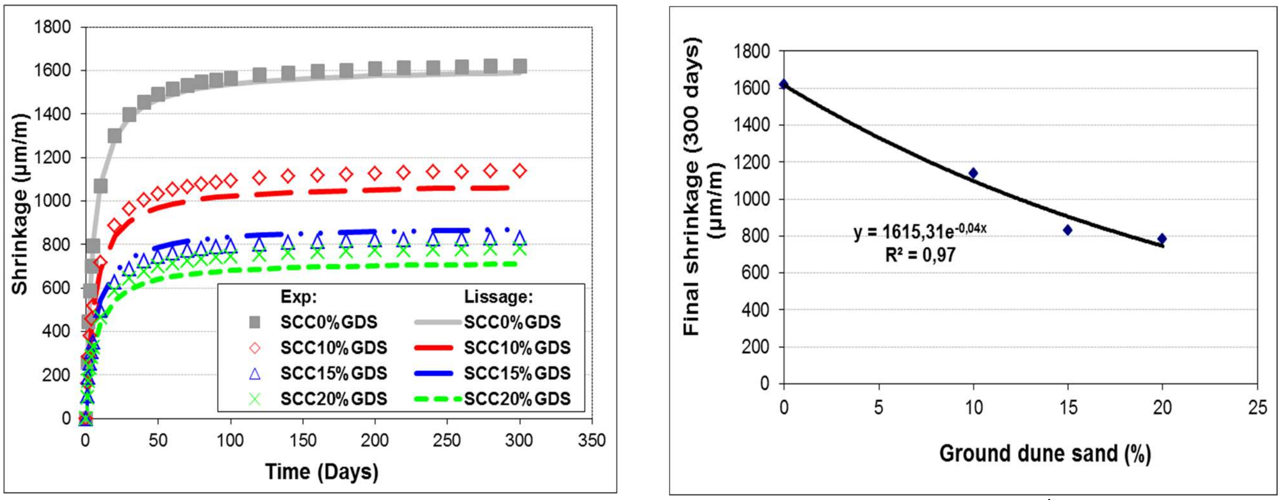
3.3.1. Experimental results of shrinkage

The effect of the incorporation of ground dune sand on the shrinkage is shown in Fig 5.a, it can be observed from that all the concrete samples shrank most within 28 days of casting (highest kinetic young), the SCC with different levels of ground dune sand develops the most significant shrinkage according to kinetics slightly different. The values of shrinkage in the specimens of SSC 0% and SCC10% were higher than that of the concrete SCC15 and SCC20 %, which the values shrinkage at the young age (28 day) of 0% and SCC10% is almost the same with the values at 360 days for SCC15 and SCC20 %, The rate of



a b

Fig. 4 - Evolution of SCC compressive strength with different percentage of GDS.



a b

Fig. 5 - **Evolution of shrinkage SCC with different percentage of GDS.**

shrinkage decreased markedly by increase in percentage of ground dune sand. The total shrinkage is closely related to the phenomenon of drying. The evaporation of water due to the hydrous gradient with the ambient conditions is done via open porosity and the micro fissuring of surface [25].

The differences in evolution of shrinkage in desiccation are connected with the porous microstructure and network; these results appear coherent with hypothesis of capillary porosity more developed in the presence of the GDS filler with higher kinetics of drying, in particular at the young age.

The Figure. 5b illustrate a correlation between final shrinkage measured at 300 days with different level of ground dune sand (GDS).good relationship exists between both final shrinkage and GDS percentage for various mixtures of self-compacting concrete are obtained, with acceptable coefficients of correlation (R^2=0.97).

The increase of amount of GDS leads to the decrease final shrinkage value; the difference is around 800μm/m between a concrete with GDS and concrete without GDS based on the experimental results.

3.3.2. Comparison with models prediction of shrinkage

The models GL2000, B3, CEB-FIB 99, ACI-209, EC2 and proposed model are used as a model for predicting the shrinkage values, Table 7 recapitulate these models of prediction and its formula.

The B3 model is the latest version in a number of shrinkage models. The first version was developed by Bazant and Panula [26]. The latest B3 model is the simpler version of BP-KX model [26, 27].The ACI-209model recommended by the American concrete Institute. The model is purely empirical, based on creep and shrinkage testing data representing the mean behavior for hundreds of tested specimens. The EC2 is applicable for

Table 7

Shrinkage of prediction models

GL2000	$\varepsilon_{sh}(t) = \varepsilon_{shu}\beta(h).\beta(t)$ ……	(1)
B3	$\varepsilon_{sh}(t) = \varepsilon_{shu}K_h.S(t)$ ……	(2)
CEB-FIB 99	$\varepsilon_{sh}(t,t_s) = \varepsilon_{cas0}(f_{cm})\beta_{as}(t) + \varepsilon_{cds0}(f_{cm})\beta_{RH}(RH).\beta_{ds}(t-t_s)$ ……	(3)
ACI-209	$\varepsilon_{sh}(t) = \left[\frac{t-t_s}{t-t_s+b}\right].K_{SS}.K_{SH}.K_{cp}\varepsilon_{shu}$ ……	(4)
EC2	$\varepsilon_{sh}(t) = \varepsilon_{sa}(t) + \varepsilon_{sd}(t)$ …… $\varepsilon_{sa}(t) = (f_{ck} - 20)[2.8 - 1.1e^{\frac{-t}{96}}]10^{-6}$ …… $\varepsilon_{sd}(t) = \frac{k(f_{ck})[72e^{-0.046f_{ck}} + 75 - \rho_h]}{1 + 0.007\frac{r_m^2}{t-t_0}} \times 10^{-6}$ ……	(5) (6) (7)

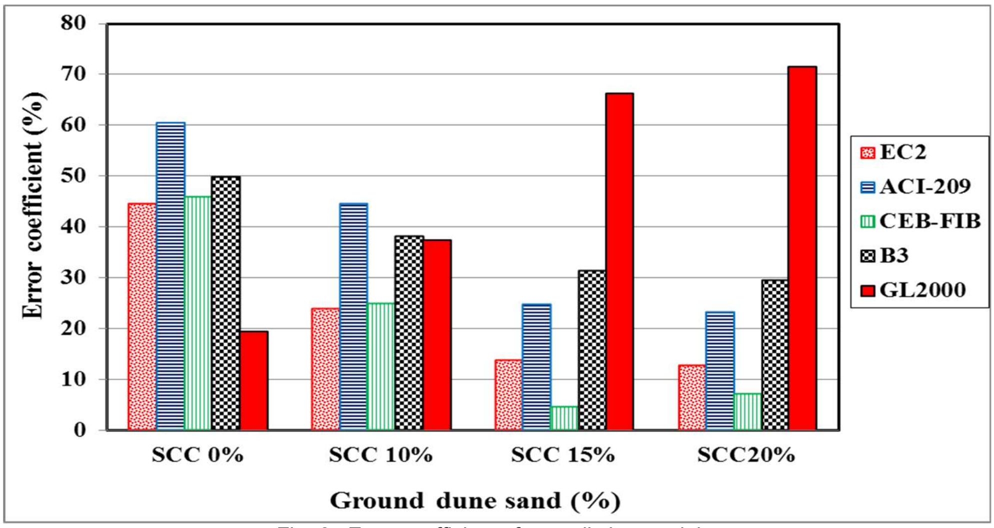


Fig. 6 - Error coefficients for prediction models.

concretes having a compressive strength at 28 days lower or equal to 90 MPa. It is based mainly on code AFREM [9].

It may be noted that only the model Eurocode 2 (EN 1992-2) considering the presence / absence of mineral addition. Indeed, it is considered in this model, specifically developed for high performance concretes [8], the presence or absence of mineral addition in the concrete composition plays a major role compared to the type of cement. With regard to the nature of cement which influence is reflected in all models, it is not given a clear rule of equivalence between the definition of the cement type used in the ACI model and Eurocode 2. The ACI model takes into account in particular the density of concrete. The CEB - FIP presents as well as mineralogical nature of the aggregates. The model B3 considers the content of cement, aggregates and water. In terms of environmental conditions, the different models include the same parameters, apart from the type of treatment considered by the only ACI 209 and B3. Although all the models use geometrical size factor translating the Specimen size, it should be noted that this one is defined differently according to the codes.

3.3. Error coefficient

The Fig. 6 shows the measure of error coefficient which determines the accuracy of different models with the experimental results, according to the following equation:

$$E(\%) = \frac{1}{n}\sum\left|\frac{\varepsilon_{cal} - \varepsilon_{exp}}{\varepsilon_{exp}}\right| \times 100 \quad (8)$$

ε_{cal} : Calculated shrinkage.
ε_{exp} : Experimental shrinkage.
n : Total number of values.

From this figure it can be observed that The comparison between the experimental results and calculated according to Eurocode 2 present a bad prediction for SCC 0%(self-compacting concrete without addition) and shows a global underestimation for this model their estimates appear satisfactory For SCC 0%, SCC 15%, and

SCC20% (error percentage is very low ≤30).this results of good prediction can be explained that the model Eurocode 2 (EN 1992-2) considering the presence / absence of mineral addition (GDS in our case), and cement type. It is specifically developed for high performance concretes.

The error coefficient presented by ACI-209 model is largest for SCC 0% and SCC 10% in comparison with others models.The ACI model is not sensitive to type of cement or addition percentage. The curing and dimensional specimen effects are taken only by ACI-209.

The prediction accuracy of CEB-FIB model is the best for SCC 15% and SCC20% comparatively with others models.it is good for SCC10% and bad for SCC 0%.The CEB-FIB model takes accounts the type of cement (Table 1).

The error coefficient is of GL-2000 and B3 very highest for SCC15% and SCC20%.small value for SCC 0% by GL-2000.

The error coefficient is the lowest for the CEB-FIB and EC2 models as compared to the other models for all concrete. They are more accurate model than the other models.

4. Conclusions

Based on the result of this research some known conclusions have been confirmed:

- It is possible to make SCC with mineral local economic additions (ground dune sand) that respect the criteria of self-compactability recommended for testing [AFGC].
- The increase in ground dune sand content improves compressive strength of SCC. The significant effect of GDS is obvious at high level of GDS 20%.
- Linear relationships between compressive strength and ground dune sand percentage with acceptable coefficients of correlation show that by increasing the GDS percentage compressive strength increases.
- The increase in GDS content reduces shrinkage of SCC. The significant effect of GDS is obvious at high level of GDS 20%.
- In the case shrinkage of SCC is compared with the prediction model. It was noted difference between the experimental and estimated results for each model.

The difference between predicted and experimental shrinkage encourage us to propose a simplified model can predict the shrinkage of concrete with admixture (GDS) better than the existing models.

REFERENCES

1. A. Tafraoui, S. Lebaili. Valorization of the sand of dune of the western erg (Algeria) in the formulation of the UHPC. Journal of Applied Sciences 2006, **13**, 2833.
2. H.A. Al-Sanad, N.F Ismael, A.J. Nayfeh. Geotechnical properties of dune sands in Kuwait. Engineering Geology 1993 ,**34** (1), 45.
3. S. Guettala, B. Mezghiche. Compressive strength and hydration with age of cement pastes containing dune sand powder. Construction and Building Materials 2011, **25** (3), 1263.
4. H. Okamura, K. Ozawa, M. Ouchi. Self-Compacting concrete, Structural Concrete 2000, **1**(1), 3.
5. A. Neville. The confused world of sulfate attack on concrete. Cement and Concrete Research 2004, **34**, (8), 1275.
6. S. Assié. Durabilité des bétons autoplaçants. Thèse de doctorat, Institut national des sciences appliquées de Toulouse France, 2004.
7. A. Makani. Analytical Estimate of the Mechanical Behavior of Rock: Granitic Aggregates. Arabian Journal for Science and Engineering 2014, **39** (5), 3651.
8. A. Tafraoui, G. Escadeillas, T. Vidal. Durability of the Ultra High Performances concrete containing Metakaolin. Construction and Building Materials 2016,**112**, 980.
9. Eurocode 2, EN 1992-2, Design of concrete structures. Concrete bridges, 2006.
10. CEB-FIP .Structural Concrete, Updated knowledge of the CEB/FIP Model Code 1990, Bulletin 1.1999.
11. ACI Committee 209. Prediction of creep, shrinkage and temperature effects in concrete structures, Detroit 1992.
12. Z.P. Bazant, S. Baweja. Short form of creep and shrinkage prediction model B3 for structures of medium sensitivity. Materials and Structures 1996, **29** (10) ,587.
13. N.J. Gardner, M.J. Lockman. Design provisions for drying shrinkage and creep of normal-strength concrete. ACI Materials Journal 2001, **98**(2), 159.
14. Z.P. Bazant, S. Baweja. Creep and shrinkage prediction model for analysis and design of concrete structures - Model B3. Materials and Structures 1995, **28**, (6), 357.
15. AFGC. Documents scientifiques et techniques - Recommandations pour l'emploi des bétons autoplaçants. Association Française de Génie Civil, Paris, France, 2008.
16. G. Habert, N. Roussel. Study of two concrete mix-design strategies to reach carbon mitigation objectives. Cement and Concrete Composites 2009, **31**(6) ,397.
17. Z. Wu, Y. Zhang, J. Zheng, Y. Ding. An experimental study on the workability of self-Compacting lightweight concrete. Construction and Building Materials 2009, **23** (5),2087.
18. K.H. Khayat, J. Assaad, J. Daczko. Comparison of field-oriented test methods to assess dynamic stability of self-consolidating concrete. ACI Material Journal 2004, **101** (2) ,168.
19. P. Nath, P. Sarker. Effect of Mixture Proportions on the Drying Shrinkage and Permeation Properties of High Strength Concrete Containing Class F Fly Ash. KSCE Journal of Civil Engineering 2013, **17** (6), 1437.
20. M. Uysal, K. Yilmaz. Effect of mineral admixtures on properties of self-compacting Concrete. Cement Concrete Composite 2011, **33** (7), 771.
21. O.A. Alawad, A. Alhozaimy, M.S. Jaafar, A. Al-Negheimish, F.N.A. Aziz. Microstructure analyses of autoclaved ground dune sand–Portland cement paste. Construction and Building Materials 2014, **65**, 14.
22. M.F. Nuruddin, K.Y. Chang, N.M. Azmee. Workability and compressive strength of ductile self-compacting concrete (DSCC) with various cement replacement materials. Construction and Building Materials. 2014, **55** (31), 153.
23. S. Guettala, B. Mezghiche, B. Belounnar. The influence of the content of cement the sand of dune finely crushed, on the characteristics of the concrete. Séminaire National sur la Gestion Intégrée des Déchets, 29 et 30 Mai, ENSET Oran; 2007. p. 195.
24. S. Guettala, B. Mezghiche, R. Chebili. Interest and effectiveness of the addition of the sand of dune finely crushed to cement, on the properties of the concrete. World J Eng 2007, 4(1), 45.
25. K. Ayed, D.Kerdal, R. Soltani. Influence of local mineral additions and volume of paste on the shrinkage of self-compacting concrete. Romanian Journal of Materials 2016, **46** (3), 405.
26. Z.P. Bazant, L. Panula. Practical prediction of time–Dependent deformations of concrete: Part I− Shrinkage. Materials and Structures 1978, **11** (65), 307.
27. D. Boucherit, S. Kenai, E. Kadri, J.M. Khatib. A Simplified Model for the Prediction of Long Term Concrete Drying Shrinkage. KSCE Journal of Civil Engineering 2014, **18** (7), 2196.

****