International Journal of Engineering

Journal Homepage: www.ije.ir

TECHNICAL NOTE

Assessment of Mechanical Properties of Concrete Containing Granite Slurry Waste

S. Sharma, T. Gupta*, R. K. Sharma

Department of Civil Engineering, College of Technology and Engineering, MPUAT, Udaipur, India

P A P E R I N F O

Paper history:
Received 04 January 2016
Received in revised form 18 March2016
Accepted 14 April 2016

Keywords:
Concrete
Granite Slurry Waste
Compressive Strength
Flexural Strength

A B S T R A C T

The granite stone is the most widely used in the construction and granite slurry is generated through cutting and polishing of the stone. Granite slurry is waste material consisting of very fine powder and creats disposal and environmental problems in worldwide today. Disposal of granite waste leads to health hazards like respiratory and allergy problems to the people around. It also causes the pollution of air and water. Concrete is the most widely used construction material and innovation in ingredient material (cement and coarse aggregate) is urgently needed. The replacement of natural resources in the production of cement is an important issue in the present construction scenario. Also, the cement industry is one of the principal producers of carbon dioxides. Utilization of granite slurry waste in concrete can solve many problems related to waste generation, reduction in the consumption of natural resources and CO_2 emission. Systematic experimental study has been carried out using granite slurry waste in place of cement at various replacement levels. This study has been carried out for w/c 0.5 and 0.4. Specimens have been cast to perform compressive strength test and flexural strength test. It has been shown that inclusion of granite slurry modifies the compressive strength and maximum strength has been obtained depending upon replacement level and w/c ratio. Flexural strength is also influenced by the addition of granite slurry waste in a similar way. These replacement studies demonstrate that the granite slurry concrete will be economically cheaper and more sustainable.

***doi**: 10.5829/idosi.ije.2016.29.05b.02*

1. INTRODUCTION

The granite stone is most widely used in the construction and massive structural works throughout the world, and it is well known in the International market, not only for its elegance and aesthetic quality, but also for its durability. The granite slurry generated during the processing will be around 40% of the final product [1]. In India, the granite industry, the amount of wastes generated in production is reached about 20 to 30% of its global production, meaning million tons of wastes from granite industries are being released from granite cutting, polishing, processing and grinding. Granite slurry is consisting of very fine powder and these waste material creating environmental problems worldwide. Disposal of granite waste leads to health hazards like respiratory and allergy problems to the people around [1]. It also causes the pollution of air and water.

*Corresponding Author's Email:*guptatrilok@rediffmail.com* (T. Gupta)

Concrete is most widely used construction material and innovation in ingredients material (cement and coarse aggregate) is urgently needed due to depleting of natural resources. The production of cement needs natural resources, high energy and it produces about 5-7% carbon dioxides [2, 3]. Also, good quality of natural sand (fine aggregate) is not available for the construction. Therefore, replacement of natural resources in the production of concrete is an important issue in the present construction scenario. The advancement of concrete technology can reduce the consumption of natural resources and energy sources, which in turn further lessen the burden of pollutants on the environment [4, 5].

Abubaker et al. [2] carried out experimental investigation on strength properties of concrete made with replacement of cement by granite slurry waste. It has been shown that up to 7.5% replacement of cement by granite slurry waste, there was no reduction in compressive strength. The tensile strength and flexural strength are also not affected due to replacement of cement by granite slurry waste up to 7.5%.

Allam et al. [6] also investigated to re-use of granite slurry waste in production of green concrete. Compressive strength of concrete was decreased (28-42%) at 15% replacement level of granite slurry waste by cement.

Divakar et al. [1] carried out experimental investigation on behavior of concrete using granite slurry as partial replacement of fine aggregates at varied replacement levels. It has been shown, that flexural strength was reduced upto 5% and compressive strength was increased 2.4%.

Arulraj et al. [7] also investigated the concrete with granite slurry waste as partial replacement of fine aggregates. The compressive strength and split tensile strength were carried out and it has been shown that highest compressive strength and split strength occur at 15% replacement of fine aggregates by granite slurry waste.

Naceri et al. [8] also carried out the effect of pozolanic admixture (waste bricks) on mechanical properties of mortar. It has been recommended that additional benefits in terms of reduction in costs, energy saving, promoting ecological balance and conservation of natural resources, etc. will be obtain by using pozzalanic admixture.

It can be seen from the above experiment studies carried out as replacement of cement/ fine aggregate that granite slurry waste can be used in concrete. Utilization of granite slurry waste in concrete will solve many problem related to waste generation, reduction in the consumption of natural resources and CO_2 emission [9-11].

In this paper, systematic experimental study carried out using granite slurry waste to replace cement at various replacement levels is presented. This study has been carried out for w/c 0.5 and 0.4 and specimens have been cast to perform compressive strength test and flexural strength test. These tests have been carried out to show the feasibility of waste granite slurry in concrete.

2. MATERIALS AND METHODOLOGY

2. 1. Materials In this systematic study cement, fine aggregates, coarse aggregates, water and granite slurry have been used to produce concrete for which properties were evaluated. Suitability of these materials have been checked in the laboratory by the performing various tests.

2. 1. 1. Cement Most widely available types of cement, ordinary Portland cement, OPC of 43 grade was used in this the investigation. The specific gravity of cement was found to be 3.11. Its initial setting time and final setting time were found to be 120 minute and 200 minute.

2. 1. 2. Fine Aggregates The locally available fine aggregate (passing through 4.75 mm sieve) was used for this study. Sieve analysis test was performed using standard testing procedure as per IS 383-1970 [12]. The fine aggregate belongs to zone–II as per IS:383-1970 (Table 1). The specific gravity of fine aggregates was found to be 2.64.

2. 1. 3. Coarse Aggregates In this Study, coarse aggregates of 20 mm and 10 mm were used. The gradation of coarse aggregates was as per IS: 383-1970 [12]. The specific gravity of coarse aggregate was found to be 2.71.

2. 1. 4. Granites Slurry The granite slurry dust collected from the cutting and polishing unit of M/S Balaji Kripa, Udaipur was used for the experimental study throughout the whole research work (Figure 1). Various tests were performed on collected granite slurry waste which was in dried form.

Tests on the chemical composition of granite slurry was carried out at Directorate of Mines & Geology, Udaipur and physical properties of granite slurry was carried out at CTAE, Udaipur to check suitability of the material and are shown in Tables 2 and 3. It can be seen from Table 2 that pozzolanic content ($SiO_2 + Al_2O_3$) of granite slurry waste is 83.70% whereas for fly ash this pozollanic content is 80.70. It is expected that granite slurry waste will provide more pozollanic activity as compared to fly ash.

TABLE 1. Sieve analysis result of fine aggregate

Sieve size	Quantity of retained (gm)	Percentage of retained	Cumulative % retained	Cumulative percentage passing
10 mm	2	0.02	0.02	99.98
4.75 mm	26	2.6	2.62	97.38
2.36 mm	19	1.9	4.52	95.48
1.18 mm	207	20.7	25.22	74.78
600 micron	386	38.6	63.82	36.18
300 micron	158	15.8	79.62	20.38
150 micron	193	19.3	98.92	1.18

Figure 1. Granite slurry waste

TABLE 2. Chemical composition of granite

SiO_2	Fe_2O_3	Al_2O_3	TiO_2	CaO	MgO	LOI	Na_2O	K_20
71.22 %	0.56 %	12.48 %	0.16 %	1.40 %	0.81 %	1.20 %	6.16 %	4.56 %

TABLE 3. Physical properties of granite

S. No.	Characteristics	Results
1.	Water Absorption	0.34%
2.	Porosity	0.89%
3.	Colour	Red
4.	Specific Gravity	2.17

2. 2. Methodology Materials such as cement, sand, coarse aggregate and Granite slurry discussed above have been used in laboratory and tested for physical properties. After testing of ingredient materials, the proportion of ingredient was finalized.

2. 2. 1. Mix Proportions In this study, the mix design of concrete M-25 grade was prepared as per IS 10262:2009 [13]. The behavior of granite slurry concrete was seen at two water cement ratios (0.5 and 0.4). In this experimental work, three series were cast. In first series, w/c ratio has been taken as 0.5 whereas in this second series has been taken as 0.4. The third series has been cast using Portland pozzolana cement (PPC) in place of ordinary Portland cement (OPC) with w/c ratio 0.4. The details of proportion ingredients to produce the concrete desired strength have been shown in Table 4.

3. RESULT AND DISCUSSION

3. 1. Workability of Concrete Workability of control concrete and the granite slurry concrete have been determine slump test (slump test as per Indian standard procedure IS:1199-1959). Table 5 shows the results of the slump test for the concrete with or without granite slurry waste at w/c ratio of 0.5. It has been also observed the result of slump test for concrete with or without granite slurry waste at w/c 0.4.

TABLE 4. Mix proportion of concrete (M-25 Grade)

Series	Specimen No.	w/c ratio	Cement type	Mix proportion by weight				
				Cement Kg/m^3	Percentage of Replacement cement by granite slurry waste	Granite slurry waste as partial replacement of cement Kg/m^3	Fine aggregates Kg/m^3	Coarse aggregates Kg/m^3
Series-I	A1	0.5	OPC	372.0	0	0.0	586	1279
	A2	0.5	OPC	353.4	5	18.6	586	1279
	A3	0.5	OPC	334.8	10	37.2	586	1279
	A4	0.5	OPC	316.2	15	55.8	586	1279
	A5	0.5	OPC	297.6	20	74.4	586	1279
	A6	0.5	OPC	279.0	25	93.0	586	1279
	A7	0.5	OPC	260.4	30	111.6	586	1279
Series-II	B1	0.4	OPC	372.0	0	0.0	586	1279
	B2	0.4	OPC	353.4	5	18.6	586	1279
	B3	0.4	OPC	334.8	10	37.2	586	1279
	B4	0.4	OPC	316.2	15	55.8	586	1279
	B5	0.4	OPC	297.6	20	74.4	586	1279
	B6	0.4	OPC	279.0	25	93.0	586	1279
	B7	0.4	OPC	260.4	30	111.6	586	1279
Series-III	C1	0.4	PPC	372.0	0	0.0	586	1279
	C2	0.4	PPC	353.4	5	18.6	586	1279
	C3	0.4	PPC	334.8	10	37.2	586	1279
	C4	0.4	PPC	316.2	15	55.8	586	1279
	C5	0.4	PPC	297.6	20	74.4	586	1279

TABLE 5. Workability of Concrete

S.no.	Specimen number	W/C	% Replacement of granite slurry waste	Slump value (mm)
1.	A1(Control Mix)	0.5	0	30
2.	A2	0.5	30	70
3.	B1(Control Mix)	0.4	0	5
4.	B2	0.4	30	10

3. 2. Compressive Strength Compressive strength of concrete specimens was determined after 7, 28 and 90 days of standard curing as per IS 516 -1959. The standard curing consist of specimens submerged immediately fresh water after demoulding and kept there until taken out just prior to test. Water, in which specimens are submerged, was renewed every 7 days and also was maintained at temperature of 27° ± 2°C. The specimens were not allowed to become dry at any time until they have been tested. This test was performed by using digital compression test apparatus (Figure 2). The graphical variation of compressive strength of concrete with different percentage level of granite slurry at w/c ratio 0.5 has been shown in Figure 3. Similarly, graphical variation of compressive strength at w/c ratio 0.4 has been also presented in Figure 4. Comparative study of modified concrete using Portland pozzolana cement in place of ordinary Portland cement has been also carried out. Graphical presentation of results using Portland pozzolana cement is also shown in Figure 5.

It can be observed from Figure 3 at w/c ratio of 0.5 that the maximum compressive strength was obtained at 5% partial replacement of cement as granite slurry waste with different interval of curing 7 days, 28 days and 90 days. Granite slurry waste has fine particles and it improves effective packing which in terms will improve microstructure. This improve microstructure will increase the compressive strength of concrete. The compressive strength decreases because replacement of cement by granite slurry waste decreases the absolute volume of cement which in turn will reduce the compressive strength.

It can be also observed from Figure 4 at w/c ratio of 0.4 that the highest compressive strength was found at 10% partial replacement of cement as granite slurry waste with different interval of curing 7 days, 28 days and 90 days. The compressive strength of concrete observed using various percentage level of partial replacement of Portland pozzolana cement in place of ordinary Portland cement have been also shown in Figure 5 (w/c ratio = 0.4). The gain in compressive strength with the inclusion of granite slurry waste by partial replacement of cement (PPC) was observed also at 5% for w/c ratio 0.4.

Figure 2. Compression Testing Machine

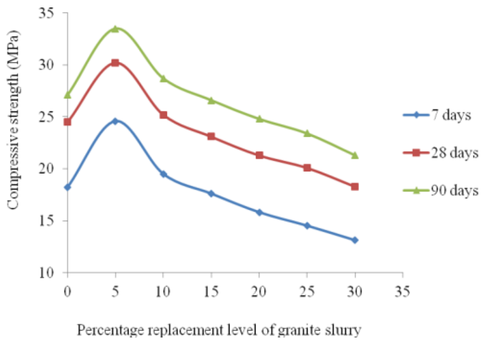

Figure 3. Compressive strength of concrete containing granite slurry waste for series-I (w/c = 0.5)

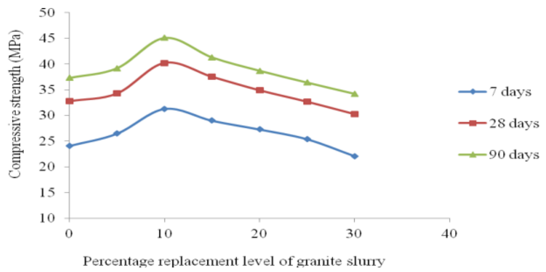

Figure 4. Compressive strength of concrete containing granite slurry waste for series- II (w/c = 0.4)

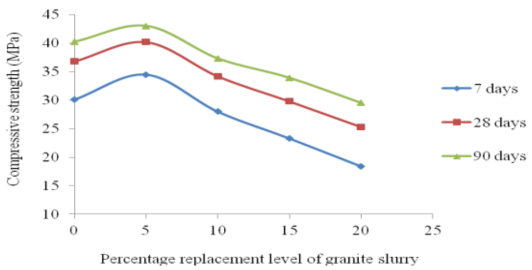

Figure 5. Compressive strength of concrete containing granite slurry waste for series-III (w/c = 0.4)

3. 3. Flexural Strength Flexural strength of concrete specimens was determined after 7 and 28 days of standard curing as per IS 516 -1959 and this test was performed by using flexural strength test apparatus (Two point load) as shown in Figure 6. The graphical variation of flexure strength of concrete with different percentage level of granite slurry at w/c ratio 0.5 has been shown in Figure 7. Similarly, graphical variation of flexure strength for this w/c ratio 0.4 has been also presented in Figure 8. Comparative study of modified concrete using Portland pozzolana cement in place of Ordinary Portland cement has been also carried out. Graphical presentation of results obtain are also shown in Figure 9.

It can be observed from Figure 7 at w/c ratio of 0.5, maximum flexural strength was obtained at 5% partial replacement of cement by granite slurry waste for curing at 7 days and 28 days.

The enhancement in concrete flexural strength at 5% partial replacement of cement by granite slurry waste is due to the microstructure improvement caused by filling effect of high fineness of granite slurry. The reduction in concrete flexural strength is seen when replacement level is more than 5%. This reduction in strength is due to reduced cement content as cement is partially replaced by granite slurry waste.

It can be also observed from Figure 8 at w/c ratio of 0.4, maximum flexural strength was found at 10 % partial replacement of cement by granite slurry waste for curing at 7 days and 28 days.

The flexural strength of concrete behavior also seen using Portland pozzolana cement in place of ordinary Portland cement (w/c ratio = 0.4). The behavior has been shown in Figure 9 and it can be also observed that maximum flexural strength was obtained at 5% partial replacement of cement by granite slurry waste for curing at 7 days and 28 days.

Figure 6. Flexure Testing Machine

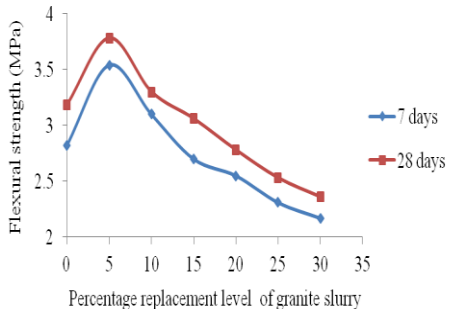

Figure 7. Flexural strength of concrete containing granite slurry waste for series-I (w/c = 0.5)

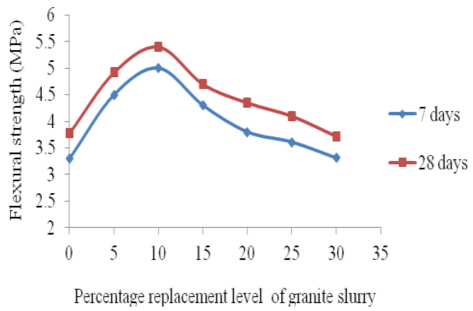

Figure 8. Flexural strength of concrete containing granite slurry waste for series-II (w/c = 0.4)

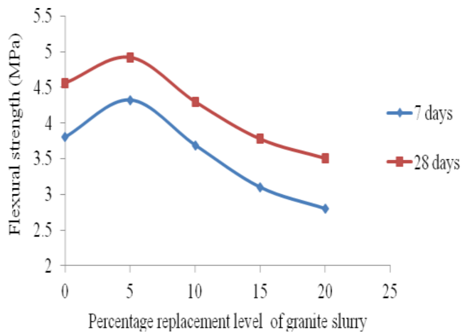

Figure 9. Flexural strength of concrete containing granite slurry waste for series-III (w/c = 0.4)

4. CONCLUSION

In this research work, cement is partially replaced by granite slurry waste at varied replacement level ranging from 0% to 30% with ordinary Portland cement and 0% to 20% for Portland pozzolana cement and suitability of this granite concrete has been evaluated. This systematic study for granite slurry concrete has been carried out for w/c ratio 0.5 and 0.4. Compressive strength and flexural strength tests have been performed for hardened concrete. Following conclusions can be drawn:

i. The slump of granite concrete is increased when cement was replaced by granite slurry waste (replacement level 30%) as compared to control mix (replacement level 0%) for w/c 0.5 & 0.4.

ii. For granite concrete, the compressive strength of concrete was increased depending upon replacement level and w/c ratio. For w/c ratio 0.5, the increase in compressive strength was observed at replacement level of 5% whereas the corresponding increase was at the replacement level of 10% for w/c ratio 0.4. When Portland pozzolana cement was used in place of ordinary Portland cement, the increase in compressive strength was observed at the replacement level of 5%.

iii. The flexural strength of concrete increased depending upon replacement level and w/c ratio for modified concrete containing granite slurry waste. For w/c ratio 0.5, the increase in flexural strength was observed at replacement level of 5% whereas for w/c ratio 0.4, the corresponding increase was at the replacement level of 10%. When Portland pozzolana cement was used in place of ordinary Portland cement, the increase in flexural strength was observed at the replacement level of 5%.

iv. Various tests performed on granite slurry concrete demonstrate that this modified concrete will perform well at partial replacement level at 5% of cement by granite slurry waste. Hence this concrete will be economically cheaper as granite slurry is waste material and freely available. Also the saving in cement will protect the natural resources and this type of concrete will be more sustainable.

v. Utilization of granite slurry waste will solve the disposal problem associated with this waste material. Also, this modified concrete will reduce the CO_2 emission because of less consumption of cement will clean the environment.

5. ACKNOWLEDGEMENT

The authors would like to thank Department of Science and Technology, New Delhi for financial support of this study (No. SB/S3/CEE/0042/2013).

6. REFERENCES

1. Divakar, Y., Manjunath, S. and Aswath, M., "Experimental investigation on behaviour of concrete with the use of granite fines", ***International Journal of Advanced Engineering Research and Studies***, Vol. 1, No. 4, (2012), 84-87.
2. Soman, K., Sasi, M.D. and Abubaker, K., "Strength properties of concrete with partial replacement of cement by granite quarry dust", ***International Journal of Engineering Research and Technology***, ESRSA Publications. Vol. 3, (2014), 149-157.
3. Pawar, M., "The significance of partial replacement of cement with waste marble powder".
4. Anwar, A., Ahmad, J., Khan, M.A., Ahmad, S. and Ahmad, S.A., "Study of compressive strength of concrete by partial replacement of cement with marble dust powder", ***International Journal on Mechanical Engineering and Robotics (IJMER)*** ISSN (Print): 2321-5747, (2014).
5. G.Latha, Reddy, A.S. and Mounika, K., "Experimental investigation on strength characteristics of concrete using waste marble powder as cementitious material", ***International Journal of Innovative Research in Science , Engineering and Technology***, Vol. 4, No. 12, (2015), 12691-12698.
6. Allam, M., Bakhoum, E. and Garas, G., "Re-use of granite sludge in producing green concrete", ***Department of Civil Engineering, National Research Centre, Egypt***, Vol. 9, No. 12, (2014).
7. Arulraj, G.P., Adin, A. and Kannan, T., "Granite powder concrete", ***IRACST. Engineering Science and Technology: An International Journal (ESTIJ)***, Vol. 3, No. 1, (2013), 193-198.
8. Naceri, A. and Chikouche Hamina, M., "Effects of pozzolanic admixture (waste bricks) on mechanical response of mortar", ***IJE Transactions B: Applications***, Vol. 21, (2008), 1-8.
9. C.Dhanalaxmi and K.Nirmalkumar, "Study on the properties of concrete incorporated with various mineral admixtures - limestone powder and marble powder", ***International Journal of Innovative Research in Science, Engineering and Technology***, Vol. 4, No. 1, (2015), 18511-18515.
10. Shirule, P., Rahman, A. and Gupta, R.D., "Partial replacement of cement with marble dust powder", ***International Journal of Advanced Engineering Research and Studies, IJAERS***, Vol. 1, No. 3, (2012), 175-177.
11. Jashandeep, S. and R.S., B., "Partial replacement of cement with waste marble powder with m25 grade", ***International Journal of Technical Research and Applications***, Vol. 3, No. 2, (2015), 202-205.
12. "Is 10262 - 2009: Guidelines for concrete mix proportioning", in, New Delhi: Bureau of Indian Standards.
13. "Is 383-1970: Specification for coarse and fine aggregates from natural source for concrete", in, New Delhi: Bureau of Indian Standards

Assessment of Mechanical Properties of Concrete Containing Granite Slurry Waste

TECHNICAL NOTE

S. Sharma, T. Gupta, R. K. Sharma

Department of Civil Engineering, College of Technology and Engineering, MPUAT, Udaipur, India

P A P E R I N F O

Paper history:
Received 04 January2016
Received in revised form 18 March 2016
Accepted 14 April 2016

Keywords:
Concrete
Granite Slurry Waste
Compressive Strength
Flexural Strength

چکیده

سنگ گرانیت، پر استفاده ترین سنگ در ساخت و ساز است و دوغاب گرانیت از طریق برش و صیقل سنگ تولید می شود. دوغاب گرانیت، مواد زائد متشکل از پودر بسیار ریز است و امروزه مشکلات دفع و زیست محیطی در سراسر جهان ایجاد می کند. دفع ضایعات گرانیت منجر به خطرات بهداشتی مانند مشکلات تنفسی و آلرژی برای مردم اطراف می شود. همچنین آن باعث آلودگی هوا و آب است. بتن، پر استفاده ترین ماده ساخت و ساز است و نوآوری در مواد تشکیل دهنده (سیمان و مصالح درشت دانه) ضروری و مورد نیاز می باشد. جایگزینی منابع طبیعی در تولید سیمان یک مسئله مهم در سناریوی ساخت و ساز موجود است. همچنین، صنعت سیمان یکی از تولید کنندگان اصلی دی کربن است. استفاده از هدر رفت دوغاب گرانیت در بتن می تواند بسیاری از مشکلات مربوط به تولید هدر رفت، کاهش در مصرف منابع طبیعی و انتشار CO_2 را حل کند. مطالعه تجربی سیستماتیک با استفاده از هدر رفت دوغاب گرانیت، به جای سیمان در محل در سطوح مختلف جایگزینی انجام شده است. این مطالعه برای ۰/۵ و ۰/٤ W/C انجام شده است. نمونه ها به منظور انجام آزمون مقاومت فشاری و آزمون استحکام خمشی قالب گیری شد. نشان داده شده است که گنجاندن دوغاب گرانیت، مقاومت فشاری را اصلاح کرده است و حداکثر قدرت بسته به سطح جایگزینی و نسبت W/C به دست آمده است. استحکام خمشی نیز با اضافه کردن هدر رفت دوغاب گرانیت با یک روش مشابه تحت تاثیر قرار می گیرد. این مطالعات جایگزینی نشان می دهد که بتن دوغاب گرانیت از لحاظ اقتصادی ارزان تر و پایدارتر خواهد بود.

doi*: 10.5829/idosi.ije.2016.29.05b.02*