Mechanical Behavior of Concrete with Cement Partially Replaced by Chewed Gum

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Abstract: Chewed gum being left on streets is a common problem everywhere and it makes the environment totally dirty, which is so costly to clear. In this research, the chewed gum was collected and stored in the freezer in order to be very brittle and easily crushed to powder, which was passed through the sieve No. 16 (1.18mm). This study investigates cement replaced by chewed gum. Eight batches were prepared to show the effect of chewed gum on the mechanical properties of concrete, through replacing the gum powder by 0.25%, 0.50%, 0.75%, 1.25%, 1.50% and 1.75% of the weight of cement to compare with the conventional concrete for w/c=0.55. The samples were tested for compressive strength and splitting tensile strength at ages of 7 and 28 days. On the basis of the experiment results, it was concluded that in general the compressive strength and splitting tensile strength decrease by increasing the chewed gum content in the concrete mix, when cement is partially replaced by chewed gum for both ages 7 and 28 days.

Keywords: Chewed Gum, Compressive Strength, Splitting Tensile Strength

1. Introduction

Concrete is one of the most common materials which plays an important role to construct a variety of civil infrastructures, due to its availability, versatility, low cost, durability, fire resistant flexibility of handling, and being able to shape into any desired form (MacGinley & Choo, 1990; Oh et al., 2017). Ordinary Portland Cement (OPC) is conventionally used as the primary binder to produce concrete (Raijiwala & Patil, 2010). The environmental issues associated with the production of OPC are observable. The amount of the carbon dioxide released during the manufacture of OPC and due to the calcination of limestone and the combustion of fossil fuel is in the order of one ton for every ton of OPC produced. In addition, the extent of energy required to produce OPC is only next to steel and aluminum (Worrell et al., 2001).

Nowadays, most of concrete technology researchers try to partially replace cement with recycled materials, in order to reduce the utilities of cement, which will be useful in terms of both environment and boosting mechanical behavior of concrete. There are various recycled materials, which are used as partially replacing materials of cement. For instance, using mosaic dust as a partially replacement of cement for enhancing the compressive strength of concrete (Mawlod & Saeed, 2017). Furthermore, some other studies focused on replacing cement with gum to improve the properties of concrete (Abdeljaleel et al., 2012; Annaamalai et al., 2015; Lachemi et al., 2004; Saleh, 2001).

Recently, researchers tried to test using gum as a local additive to test the possibility of increasing the workability of concrete to produce high performance concrete. According to Annaamalai et al. (2015) replacing cement with natural gum the optimum compressive and splitting tensile strength can be achieved when gum is replaced by 1.2% of the weight of cement at the ages of 7 and 28 days. Similarly, Saleh (2001) investigated the effect of Gum Arabic liquid in concrete mixes to obtain high compressive strength concrete and good workability. Likewise, Akasha et al. (2016) revealed that compressive strength of concrete rises with increasing the Acacia Tortilis gum content in concrete and the optimum ratio is 0.5%. In contrast, Abdeljaleel (2012) determined that the compressive strength of concrete decreases with increase of natural Arabic gum powder content in concrete. Lachemi et al. (2004) complained that in general, gums reduce compressive strength in concrete due to increased viscosity.

On the base of the contrast results, previous researches concluded that using chewed gum in the concrete as partially replaced cement is remained as a gap. So, in this research, an attempt is made to use chewed gum as a partial replacement of cement to detect the changing of the mechanical behavior of concrete. The structure of this paper is as follow. In section 2, the experimental materials are presented, while, section 3 shows experimental methodology. Section 4 introduces the results and discussions. Finally, a concluding summary is presented in section 5.

2. Experimental Material

2.1 Cement

Ordinary Portland Cement (OPC) was used for entire experimental mixes of the study as shown in Figure 1. The chemical and physical properties of the cement are shown in Tables 1 and 2 respectively, which are conformed to IQ.S 5/1984 Standard for Ordinary Portland Cement. The specific gravity of the cement is 3.14 (Mawlod & Saeed, 2017).

Table 1: Chemical Properties of cement (OPC)

Chemical requirements	IQ.S 51984 Standard for Ordinary Portland Cement	
	Limitation	Test Results
Lime saturation coefficient%	0.66-1.02	1
Magnesium Oxide (as MgO)%	≤5	3.6
Sulfate content (as SO3)%	2.5 if C3A ≤5	2.2
	2.8 if C3A ≥5	
Loss of ignition (as LOI) %	≤4.0	3.5
Non Soluble Substance %	≤1.5	0.8

Table 2: Physical properties of cement (OPC)

Physical Requirements	IQ.S 51984 Standard for Ordinary Portland Cement	
	Limitation	Teat Results
Fineness (Blaine)kg/m²	≥230	343
Initial Setting time minute	≥45	150
Final Setting time hour	≤10	3:20
Soundness (expansion) %	≤0.8	0.2
Compressive strength is not less than (MN/m²)	≥15.0	35.7
	≥23.0	46.0

2.2 Aggregates

2.2.1 Course Aggregate

In this research, the crushed stone was used, as shown in Figure 3, which is locally available. It was lime stone type which was extracted from mountains of Penjwen and Sayed-Sadiq district, and was homogenous and free from deleterious substances. The shape of crushed stone was normally angular and of rough surface texture, with yellow to white color. The maximum size of 9.5mm was used in this study. Samples of gravel are taken several times and sieved to achieve the densest possible concrete, so as to be fit with the standard specification ASTM-C33 (2003), for coarse aggregate (see Table 3 and Figure 1). The physical properties and chemical composition of the crushed stones are given in Tables 4 and 5 respectively (Khoshavi, 2005; Saeed, 2010).

Table 3: Grading of Coarse Aggregate with ASTM-C33 (2003) limits

No	Sieve No, mm	Passing %	ASTM-C33limits
1	12.5	100	100
2	9.5	88.74	85-100
3	4.75	26.91	10-30
4	2.36	1.37	0-10
5	1.18	0.95	0-5
Fineness Modulus	2.18		
Specific Gravity	2.55		

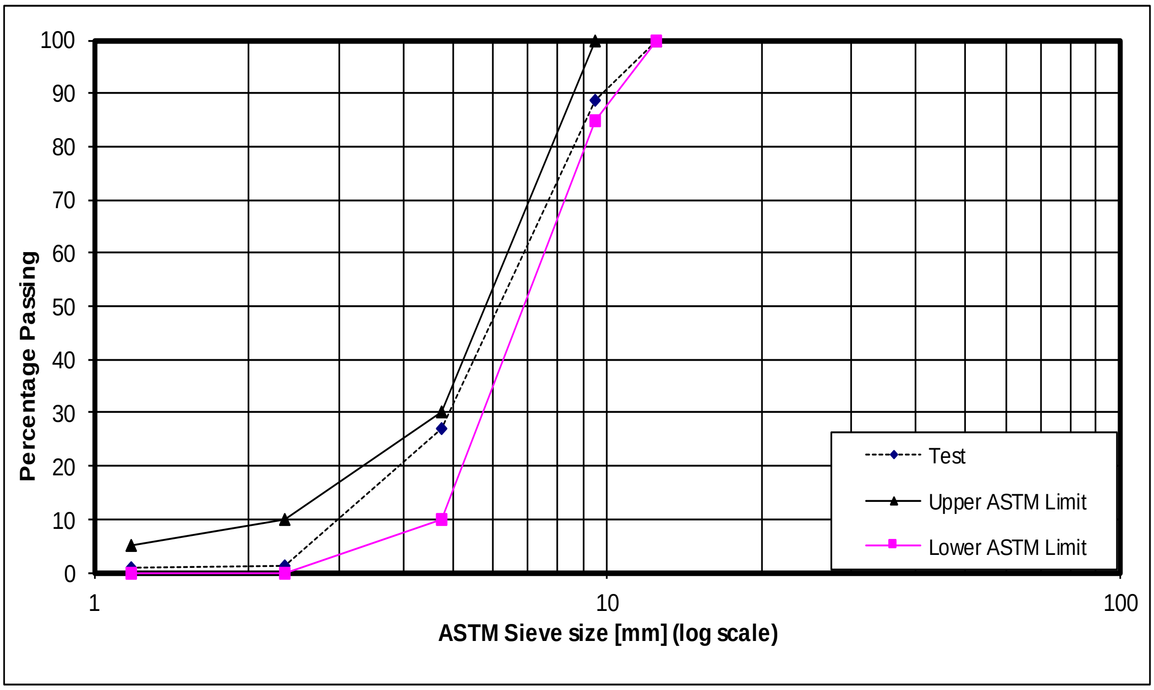

Figure 1: Grading curve for the coarse aggregate with ASTM-C33 (2003) limits

Table 4: Physical properties of selected limestone

Bulk Specific Gravity	Compressive Strength N/mm^2	Absorption %	Wear Abrasion %	Impact Resistance
2.18	33.4	3.05	15.7	9

Table 5: Chemical Composition of Selected Limestone

SO_3 %	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	MgO %	CaO %	Loss on Ignition %
0.1	0.7	0.6	0.9	0.2	55.0	42.5

2.2.2 Fine Aggregates

The locally available river natural sand has been used as fine aggregate in this study, as shown in Figure 3. To achieve the densest possible concrete, the well-graded sand was chosen according to ASTM-C33 (2003) standard specification for fine aggregate (see Table 6 and Figure 2). The specific gravity of sand is 2.40 and fineness modulus is 4.20.

Table 6: Grading of Fine Aggregate with ASTM-C33 (2003) limits

No	Sieve No, mm	Passing %	ASTM-C33limits
1	9.5	100	100
2	4.75	95.55	95-100
3	2.36	82.53	75-100
4	1.18	65.76	50-85
5	0.6	48.75	25-60
6	0.300	25.61	5-30
7	0.150	6.15	0-10
Fineness Modulus	4.24		
Specific Gravity	2.40		

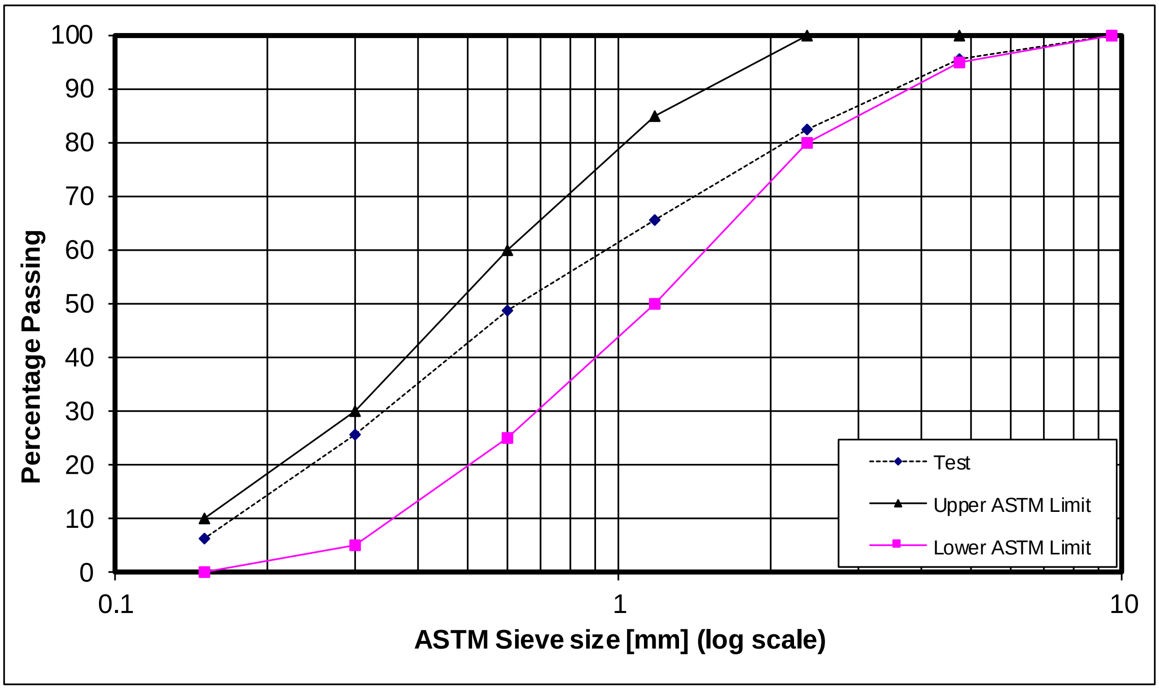

Figure 2: Grading curve for the fine aggregate with ASTM-C33 (2003) limits

2.3 Water

Water is the important component of concrete as it is involved in the chemical reaction with cement and it helps to the strength by giving cement gel. In the investigation drinkable water is also used for mixing and curing. The quality of water was observed carefully, it was free from organic materials and oil.

2.4 Gum

Chewed gum is collected one by one and kept in the freezer to be hard and brittle so as to crush easily as shown in Figure 3. The crushed chewed gum was immediately added to the mixture after passing through sieve 1.18mm.

Figure 3: Experimental Material

3. Experimental Methodology

In this experiment, the chewed gum, which is used as partially cement replacement was evaluated. Eight mixes were prepared with replacing chewed gum by 0%, 0.25%, 0.50%, 0.75%, 1.00%, 1.25%, 1.50% and 1.75% of the weight of the original required cement to compare with the conventional concrete for water to cement ratio (w/c=0.55). For each of the batches 6 cubes and 6 cylinders were casted. The molds are lubricated before casting concrete and are opened after 24 hours then placed in the water tank for the curing purpose for 7 and 28 days. The cubes are removed from water before testing in order to avoid the internal water pressure inside the concrete voids. The samples were tested to have compressive strength and splitting tensile strength at ages of 7 and 28 days to show the effect of chewed gum on the mechanical properties of concrete.

Table 7: Mix design w/c= 0.55 for 37 liters of concrete batch

All units in (g)		Ratio of chewed Gum to the original required of cement (13952.6g)							
		0%	0.25%	0.50%	0.75%	1.00%	1.25%	1.50%	1.75%
Materials	Cement	13952.6	13917.7	13882.8	13848.0	13813.1	13778.2	13743.3	13708.4
	Gum	0	34.9	69.8	104.6	139.5	174.4	209.3	244.2
	Water	7674	7674	7674	7674	7674	7674	7674	7674
	Gravel	41858	41858	41858	41858	41858	41858	41858	41858
	Sand	27905.3	27905.3	27905.3	27905.3	27905.3	27905.3	27905.3	27905.3
	Total	91389.9	91389.9	91389.9	91389.9	91389.9	91389.9	91389.9	91389.9

4. Results and Discussion

4.1 Compressive Strength

Table 8 and Figure 4 show the behavior of the compressive strength of concrete cube samples with partially cement replacement by the chewed gum. The compressive strength continuously decreases with increasing chewed gum content at the age of 7 days. However, there are some fluctuations with increasing the gum content at the age 28 days. This may due to the fact that chewed gum is very sensitive to temperature, thus it turns to ball and agglomerate, which makes the compressive strength oscillate by adding chewed gum concrete. It is essential to mention that at the beginning, supposedly the results made no sense and they cannot be explained. For that reason, all tests were repeated accurately. Surprisingly, the second trial of the experiment had similar results. Therefore, it can be said that cement replaced with chewed gum reduces the compressive strength.

Table 8: Compressive strength at 7 & 28 days

Chewed Gum %	Compressive Strength (7 days) (MPa)	Compressive Strength (28 days) (MPa)
0.00	36.06	42.89
0.25	33.87	43.32
0.50	31.46	42.64
0.75	31.43	41.95
1.00	32.74	43.04
1.25	30.41	42.20
1.50	29.28	38.90
1.75	28.39	39.71

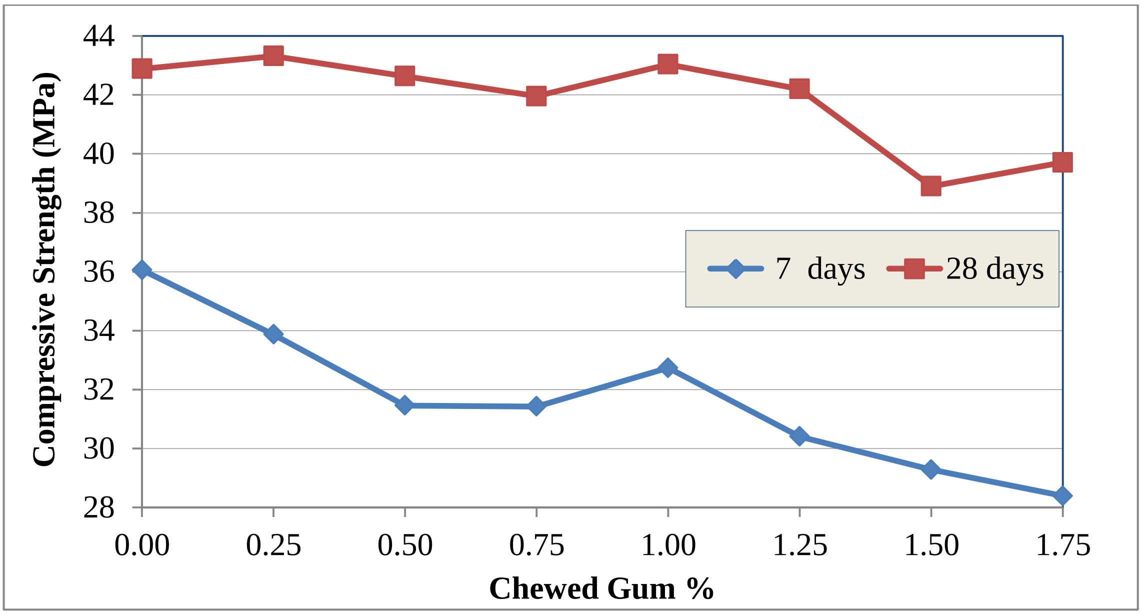

Figure 4: Compressive strength

4.2 Splitting Tensile Strength

The results of the splitting tensile strength are shown in the Table 9 and Figure 5. Similarly, the spitting tensile strength didn't have a smooth tend with increasing the chewed gum content for both ages of 7 and 28 days. The nature of synthetic gum, when the temperature is dropped, randomly tends to be more cohesive which makes the concrete weak. Also the gum may work as a space inside the concrete mass. As the results are generally unfamiliar, the work is repeated twice to get accurate results. And the results were the same as the first experiment. Overall, it can be concluded that the use of chewed gum as partially replacement of cement weakens the splitting tensile strength because the agglomerated gum works as a weak point inside the concrete.

Table 9: Splitting tensile strength 7 & 28 days

Chewed Gum %	Splitting Tensile Strength (7 days) (MPa)	Splitting Tensile Strength (28 days) (MPa)
0	2.51	3.07
0.25	2.37	3.01
0.50	2.27	2.62
0.75	2.47	2.92
1.00	2.42	2.89
1.25	2.13	2.68
1.50	2.50	2.70
1.75	2.13	2.64

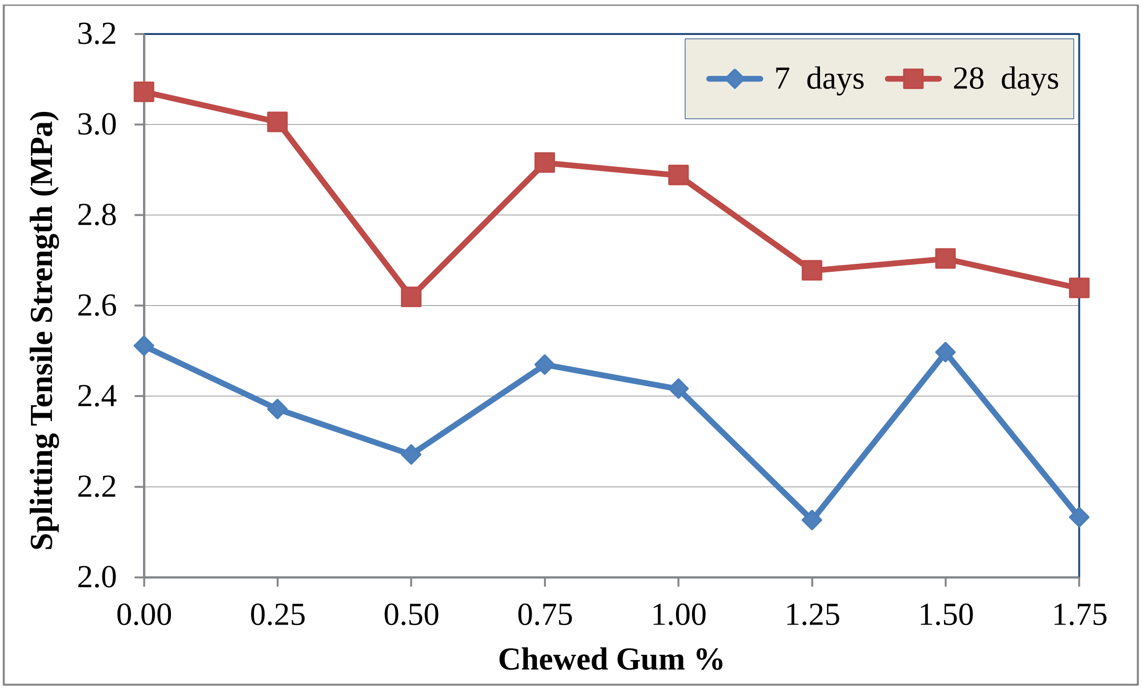

Figure 5: Splitting tensile strength

5. Conclusion

On the basis of the experiment results, the following conclusions are drawn:

1. Compressive strength generally decreases with increasing the chewed gum content in the concrete mixture, when cement is partially replaced by the chewed gum for both ages 7 and 28 days

2. When cement is partially replaced by the chewed gum, splitting tensile strength generally falls down with rising the chewed gum content in the concrete mixture for both ages 7 and 28 days

3. The chewed gum have a behavior of fluctuation in compressive strength and splitting tensile strength with increasing chewed gum content randomly for both ages 7 and 28 days. This may be due to the reason that the replaced material becomes randomly cohesive with rising temperature due to hydration.

References

Abdeljaleel, N. S., Hassaballa, A. E., & Mohamed, A. R. E. (2012). The Effects of Gum Arabic Powder and Liquid On the Properties of Fresh and Hardened Concrete. *International Journal of Engineering Inventions*, 1(12), 57-65.

Akasha, N. M., Moh, M. A., & Othman, S. A. (2016). The Effect of Acacia Tortilis Gums on the Properties of Fresh and Hardened Concrete. *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, 13(2), 75-80.

Annaamalai, M. G. L., Maheswaran, G., Yuvaraja, R., & Jayakodi, R. (2015). Effect of Partial Replacement of Cement with Neem Gum on the Strength Characteristics of High Performance Concrete. *International Journal of Chemtech research*, 8(1), 178-183.

ASTM-C33 (2003). *Standard Specification for Concrete Aggregates*. Annual Book of ASTM Standards, ASTM International, West Conshohocken, PA.

Khoshavi, H. I. (2005). *Shear Strength and Behavior of Crushed Stone Reinforced Concrete Deep Beams with Web Openings* (Master Thesis). University of Salahaddin.

Lachemi, M., Hossain, K., Lambros, V., Nkinamubanzi, P.C., & Bouzoubaâ, N. (2004). Self-consolidating concrete incorporating new viscosity modifying admixtures. *Cement and Concrete Research*, 34(6), 917-926.

MacGinley, T. J., & Choo, B. S., (1990). *Reinforced Concrete: Design Theory and Examples*. Second Edition. CRC Press.

Mawlod, A. O., & Saeed, N. M. (2017). Impact of Cement Replacement Partially by Mosaic powder on Compressive Strength of Concrete. *Eurasian Journal of Science & Engineering, (EAJSE)*, 2(2), 9-18.

Oh, T.K., Kim, J., Lee, C., & Park, S. (2017). Nondestructive concrete strength estimation based on electro-mechanical impedance with artificial neural network. *Journal of Advanced Concrete Technology*, 15(3), 94-102.

Raijiwala, D., & Patil, H. (2010). Geopolymer concrete A green concrete, Chemical, Biological and Environmental Engineering (ICBEE), 2010 2nd International Conference on. IEEE, pp. 202-206.

Saeed, N. M. (2010). *Shear Strength And Behavior of Crushed Stone High Strength Reinforced Concrete Deep Beams Without Horizontal Reinforcement.* Thesis (MSc). University of Sulaimani.

Saleh, A. M. (2001). *To Obtain High-Strength Concrete and the Resistance through the Improvement of Natural Additions.*Moscow Thesis (PhD). International University of Civil Engineering.

Worrell, E., Price, L., Martin, N., Hendriks, C., & Meida, L. O. (2001). Carbon Dioxide Emissions from the Global Cement Industry. *Annual review of energy and the environment*, 26(1), 303-329.