

高架桥路交通噪声主观反应调查研究

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摘要 采用调查表与噪声测量同步进行的方法研究人们对城市高架桥路交通噪声的主观反应, 分析了主观烦恼度、睡眠干扰率随等效声级变化的规律, 指出不同人群主观烦恼反应、睡眠干扰反应的差异, 高架桥路建设前后及非高架桥路主观反应的差异。

关键词 交通噪声, 高架桥路, 主观反应, 主观烦恼度, 睡眠干扰。

高架桥与高架路(以下合称高架桥路)交通噪声多数高于地面道路交通噪声。为了较好地了解人们对高架桥路交通噪声的主观反应, 分析高架桥路交通噪声对人们的影响, 1994年和1995年针对居住和工作在青岛市高架与非高架桥路两侧临街建筑物内的人群, 分发表格进行主观反应调查, 同时进行噪声测量。通过计算机对调查资料与声级测量结果进行分析, 得到主观反应与交通噪声的相关关系, 较好地反映了高架桥路交通噪声对人们影响的一些特点, 为高架桥路的规划建设防噪对策提供了人群主观反应的依据。

1 调查与分析方法

1.1 噪声测量方法

为研究高架桥路交通噪声的主观反应, 在测量高架桥路交通噪声的同时, 对同一道路的非高架路段也选点测量。噪声测量点多数选在被调查者临街居住或工作的各层楼室外1m处, 高架与非高架桥路测点数之比为3:4, 共86个测点, 其中2/3的测点分白天、早晚和夜

间3个时段测量, 1/3的测点为昼夜24h连续测量。仪器为符合测试规范的噪声自动监测仪器, 评价量为等效A声级。

1.2 主观反应调查方法

主观反应调查对象为测点同一侧的卧室、办公室内的人群, 每个测点平均调查约35人。调查表格内容, 其一为被调查者的基本情况, 其二为被调查者对噪声的主观反应, 调查方式为通过街道办事处和居委会向被调查者发放表格, 讲明填表方法, 不作任何暗示, 被调查者亲自填写。

1.3 调查与测量数据处理方法

用回归分析方法, 将调查所得各项数据和测得声级数据进行分档, 由计算机计算出两者各相应等级的相关性与百分率。

2 主观反应调查统计结果

发放调查表数与实际收回完整有效表格数见表1, 收回合格表格的被调查人群的概况如表2所示。

由表1可以看出, 两次调查表的收回率均

表1 调查表发放与收回情况

时间 /a	总 表 格			高 架 桥 路			非 高 架 桥 路		
	发放/份	收回/份	收回率/%	发放/份	收回/份	收回率/%	发放/份	收回/份	收回率/%
1994	3000	1986	66.2	2250	1518	67.3	750	470	62.6
1995	1000	706	70.6	750	560	74.6	250	157	62.7

是高架高于非高架桥路, 这表明人们对高架桥路交通噪声反应更强烈。

表2 被调查人群基本情况

被调查 人 群	性 别		年 龄				职业性质		健康状况	居 住 楼 层			居 住 时 间/ <i>a</i>		
	男	女	老	中	青	脑	体	健 病		1—2	3—4	5	1—2	3—4	5
人 数	1035	681	856	935	195	661	1325	1731	255	693	579	714	124	315	1547
百分率	65.7	34.3	43.1	47.1	9.8	33.3	66.7	87.2	12.8	34.9	29.2	35.9	6.2	15.9	77.9

3 主观烦恼度分析

主观烦恼度的分级,按7个等级列表调查.考虑到目前我国城市人群的居住和办公条件普遍处于较低水平,再按4个等级归纳分类,即不烦恼(含根本不烦恼,不烦,无所谓)、略有烦恼、烦恼、很烦恼(含相当烦恼和烦得不可忍受),并将 、 定为高烦恼度加以分析.

3.1 烦恼度与交通噪声的关系

高架桥路与非高架桥路的白天烦恼反应随等效声级变化关系见图1.由图1可知,高架桥路与非高架桥路的不同等级烦恼反应随等效声级的变化曲线是近似的,与国内外调查一般城市道路交通噪声所得结果基本相似^[1],随着声级的升高,低烦恼级人群的百分比由高逐渐降低,高烦恼级人群的百分比逐渐升高,但因个体反应的差异,即使在较低声级,仍有少数人感到很烦恼;同样,在较高声级时,也有个别人不感到烦恼.图1表明,白天 L_{eq} 60dB(A)时,高烦恼

率处于低水平.

3.2 不同人群的高烦恼度

表3列出了不同人群白天高烦恼率与等效A声级的关系;白天高架路与非高架桥路临街楼不同楼层人群的高烦恼率曲线如图2所示.

表3 白天不同人群的高烦恼率随等效声级的变化/ %

等效声级 /dB(A)	50	53	56	59	62	65	68	71	74	77	80
性 别	男	35	39	48	57	55	64	58	70	71	75
	女	22	32	39	48	56	55	60	61	60	72
年 龄	老	27	25	28	50	58	70	65	66	71	74
	中	24	26	24	48	60	66	68	62	70	73
	青	17	20	22	30	44	42	52	58	64	66
职业性质	脑	20	20	24	43	58	56	66	65	71	76
	体	19	24	19	35	37	52	60	57	64	69
健康状况	健	17	20	18	45	43	52	54	56	65	62
	病	35	30	31	66	65	64	72	70	78	75

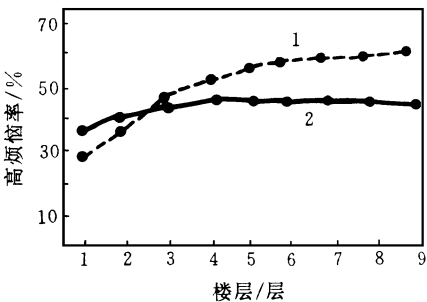


图2 白天烦恼反应的临街不同楼层变化关系
1. 高架桥路 2. 非高架桥路

表3表明,高架桥路两侧的不同人群随着交通噪声声级的升高,其高烦恼率均是增加趋势,但在相同声级条件下,不同人群间则有差异,其中性别不同对烦恼度反应无明显差异,男女性别在各个声级值上的高烦恼率基本接近,平均相差0.9%;不同年龄的人群中,中老年人的高烦恼率比较接近,平均相差1.3%;而青年人的高烦恼率则低于中老年人,平均低10.8%,脑力劳动者高烦恼率高于体力劳动者,平均高出6.2%;病人的高烦恼率高于健康人,

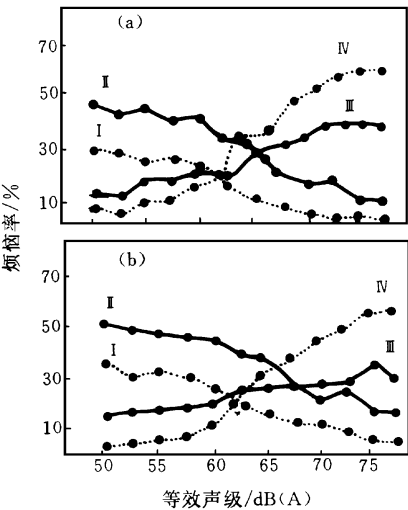


图1 白天烦恼反应随声级变化关系
(a) 高架桥路 (b) 非高架桥路

平均高出15.2%。可见中老年人比青年人对交通噪声易感到烦恼,脑力劳动者、病人更需要安静的环境。

由图2可知,高架桥路两侧居民楼内人群的高烦恼率在低层低于非高架路的两侧楼内者,而中、高层高于非高架桥路者,这与高架桥路噪声源的抬高及构成复合声场相一致^[3]。

4 睡眠干扰反应

睡眠干扰反应的调查按无影响、有时有影响、经常有影响、有时被吵醒或较难入睡及经常被吵醒或极难入睡5个等级分档,将后3种归为高干扰率,与等效声级相关联作分析。夜间睡眠高干扰率与噪声级的关系示于图3。不同人群夜间睡眠高干扰率与高架桥路两侧临街等效声级关系见表4。高架桥路建设前后及非高架路的两侧临街不同楼层人群夜间高睡眠干扰率如图4所示。

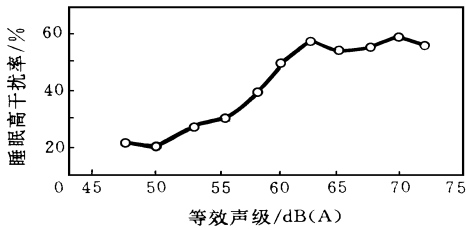


图3 夜间睡眠高干扰反应随声级变化关系

表4 夜间不同人群睡眠高干扰随等效声级的变化/ %

等效声级 / dB(A)	44	47	50	53	56	59	62	65	68	71	74
性别男	27	31	30	50	60	64	75	74	76	75	76
性别女	25	36	34	52	56	60	72	75	70	74	79
年龄老	30	38	42	58	69	67	70	68	75	78	70
年龄中	32	33	38	55	68	69	72	71	70	73	75
年龄青	27	24	28	34	50	56	54	57	62	64	68
职业脑力	38	25	44	58	62	72	71	73	78	81	76
职业体力	34	20	40	48	64	68	67	70	72	74	75
健康状况健	18	25	35	46	42	44	56	70	72	71	74
健康状况病	32	34	40	56	62	64	76	80	87	78	77

由表4和图3可知,与烦恼反应类似,各人群的睡眠高干扰反应随着高架桥路交通噪声声级的升高,均呈增加趋势,但在相同声级条件下,

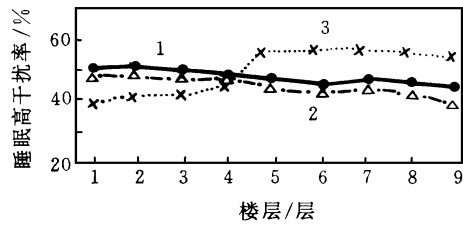


图4 夜间睡眠高干扰反应的临街不同楼层变化关系

1. 非高架桥路 2. 高架桥路(建成前)
3. 高架桥路(建成后)

不同人群的睡眠干扰率也有一定差异。中老年人之间较近似,平均相差0.8%,中老年人比青年人高,平均高13.2%;脑力劳动者高于体力劳动者,平均高4.2%;病人高于健康者,平均高12.1%;而男女性别之间差别很小,平均差值为0.5%。这说明中老年人、脑力劳动者与病人更需要安静的睡眠环境。一般地,夜间 $L_{eq} 50\text{dB}$ (A)时,睡眠高干扰率处于低水平。

居住在临街低层的人普遍感到睡眠干扰建桥前高于建桥后,而中高层的人们感到建桥后睡眠干扰程度比建桥前增高了。由图4可知,建桥前与非高架桥路的高睡眠干扰变化曲线近似,但非高架桥路比建桥前的高睡眠干扰曲线略有增高,这是建桥后道路畅通车流量增加、车速加大而使同一条路的非高架桥路的噪声级升高所致。建桥后低层楼睡眠高干扰率低的原因是建桥后地面车流量有所减少。

5 不同人群主观反应的声级阈值差

对同一声级值的不同人群有不同主观反应,其原因在于不同人群之间主观反应的声级阈值不同,不同人群主观反应差异对应的等效声级阈值差列于表5。

由表5可知,在男女性别之间主观反应的声级阈值差较小,青年人与中老年人之间、脑体劳动者之间、健康与非健康者之间在调查的主观反应上均有明显差异。但在思考干扰和语言干扰反应上,脑体劳动者之间声级阈值差为负值,表明脑力劳动者在噪声环境中思考交谈的抗干扰能力比体力劳动者强。

表5 不同人群主观反应差异对应的声级阈值差

反应类型		男-女	青年-中老年	脑力-体力	健康-非健康
烦恼度/ 昼	阈值差/ dB(A)	0. 3	4. 2	1. 8	4. 6
	高干扰率/ %	0. 9	10. 8	6. 2	6. 5
睡眠干扰/ 夜	阈值差/ dB(A)	0. 7	6. 3	2. 2	6. 5
	高干扰率/ %	0. 5	13. 2	4. 9	12. 1
思考干扰/ 昼	阈值差/ dB(A)	0. 4	1. 2	- 1. 0	1. 5
	高干扰率/ %	0. 2	6. 6	9. 8	7. 9
语言干扰/ 昼	阈值差/ dB(A)	0. 6	2. 1	- 0. 8	3. 5
	高干扰率/ %	1. 2	9. 7	8. 8	15. 8

6 小 结

- (1) 现场调查与声级测量的研究表明, 对交通噪声的所有主观反应, 高反应率均随交通噪声的增大而增高, 但由于个体的差异, 少数人的反应不遵循这一规律.
- (2) 高架桥路建成后, 人群的主观高反应率普遍升高了, 这为城市高架桥路和临街建筑的规划设计提供了依据. 比如, 不在高架桥路附近建高层建筑或高架桥路尽量避开临近高层建筑群. 若不可避免时, 应加大防噪措施.
- (3) 不同人群对高架桥路噪声主观反应百

分率的差异大小与其主观反应声级阈值差的大小相一致.

(4) 高架桥路两侧噪声等效声级昼间 60dB(A) , 夜间 50dB(A) 时, 不同人群主观高反应率均处于低水平, 这对高架桥路而言是不易达到的环境噪声水平.

参 考 文 献

1 赵仁兴. 噪声与振动控制, 1994. 10(5) : 20

2 柳孝图. 噪声与振动控制, 1989. 8(4) : 22

3 陈子明等. 环境科学, 1994. 4(11) : 24

4 Lambert J et al. . Journal of Sound and Vibration, 1984, 92 (2) : 159

(上接第40页)

表2 卡那霉素废水厌氧处理实验

操作负荷/ kg•d ⁻¹ •m ⁻³	10	20	30	30	40
进料 COD 浓度/ mg•L ⁻¹	1200 ²⁾	3200 ²⁾	5000 ²⁾	5000+ 2000 ¹⁾	5000+ 2000 ¹⁾
出料 COD 浓度/ mg•L ⁻¹	500	1120	2670	1100	2000
COD 去除率/ %	71. 0	65. 3	46. 6	84. 3	71. 0
出料 NH ₃ -N/ mg•L ⁻¹		400	720	401	521
COD 降解速率/ kg•d ⁻¹ •m ⁻³	7. 1	9. 8	9. 6	23. 4	34. 0

1) 进料 COD 浓度中5000mg/L 来自卡那霉素废水, 2000mg/L 来自啤酒废水 2) 由卡那霉素废水加水配制而成

3 结 论

- (1) 填充床酸化反应器启动方便, 酸化速率高, 容积负荷大, 具有较强的抗水力冲击和抗 pH 波动的能力, 优于 CSTR 和 UASB 酸化反应器.
- (2) 以填充床酸化反应器与 UASB 甲烷化反应器组成的二相厌氧消化系统, 采用预调碱工艺, 运行正常.
- (3) 经合理设计和控制的二相消化系统可有效地处理啤酒废水和金霉素废水. 在40kg/

(d•m³) 负荷条件下处理啤酒废水, 排放水 COD 浓度可控制在200mg/L 以下, 对卡那霉素废水有一定的处理效果.

参 考 文 献

1 严月根. 中国环境科学, 1990, 10(4) : 304

2 郭养浩. 微生物学通报, 1995, 22(5) : 289

3 Cohen A et al. . Water Research, 1979, 13: 571

4 杨虹. 上海交通大学学报, 1995, 29(5) : 165

5 Zoenemeyer R J et al. . Water Research, 1982, 16: 303

6 王蕾. 环境科学, 1992, 13(3) : 51

7 刘双江. 环境科学, 1991, 12(3) : 7

leached for ten years are more than 7, except the brown earth which become acid under pH 2 in the fourth year. The total losses of the leached base ions are: After ten years leaching, lime concretion black soil > salt-affected soil > chao soil > brown earth. The sensitivity of base ions to acid rain are: $\text{Ca}^{2+} > \text{Mg}^{2+} > \text{K}^+, \text{Na}^+$. The simulated acid rain has activation to the aluminium in the soils. There is no active aluminium in the four types of soils except the brown earth which the active aluminium appears in pH2. It has obvious improvement effect to apply lime to the acid brown earth.

Key words: simulated acid rain, simulated earth volume test, physical and chemical properties of soil, active aluminium.

A Study on the Treatment of Black Liquor from Bamboo Pulping Process with Sequencing Batch Reactor Biological Technique. Yan Shanghua, Chen Min et al. (Guangdong University of Technology, Guangzhou 510090): *Chin. J. Environ. Sci.*, **18**(3), 1997, pp. 30_33

In this paper, the treatment of bamboo pulping black liquor in which lignin has been separated by acid with sequencing batch reactor (SBR) was investigated. The experimental results showed that BOD₅ and COD in black liquor increased remarkably with the treatment of SBR, BOD₅ removal rate is 70%—83%, COD removal rate is 54.5%—63%, the effluent BOD₅ and COD after the treatment are 76—101 mg/L and 419—500mg/L respectively when influent COD is 1090—1170mg/L. The technology of combining internal decomposition with SBR is more efficient for treatment of black liquor, BOD₅ and COD removal rate are 67%—68% and 71.4%—76.9% respectively, the effluent BOD₅ and COD from this system are 33—48mg/L and 242—315mg/L respectively when influent COD is 1046—1100mg/L. It is in keeping with GB8978-88 effluent standard. The internal decomposition remarkably increase the effectiveness of follow-up SBR treatment. In addition, the kinetics of first order degradation reaction of COD was studied. The kinetic constant and undegradable COD had been calculated. Simulated data tally with experimental data well.

Key words: SBR, biological technique, internal decomposition, bamboo pulp, black liquor, biological degradation, sequencing batch reactor.

Study on the Formula of Expansion Characteristic of Three-phase Biological Fluidized Bed. Pan Tao, Wu Yangshan, Wang Shaotang

(Beijing Municipal Research Academy of Environmental Protection, Beijing 100037): *Chin. J. Environ. Sci.*, **18**(3), 1997, pp. 34_37

The formula of expansion characteristic in the three-phase biological fluidized bed has been founded in this study. When the empty-bed velocity of liquid and gas as well as the thickness of bio-film are known, the high of bed expansion is determined rather precisely, which provided basis for design. It is unusual that the expand ruler in both the two-phase bed and three-phase fluidized bed are reflected by using one equivalent function; the relationship of the dynamic in biochemical reaction and behavior of hydromechanics has been set up by the thickness of bio-film. The behavior of shrink in bed under the low velocity of gas can be reflected by this formula, and the formula in three-phase bed can be restored to one in two phase bed when the velocity of gas is zero. The tested bed is 1.4m of diameter and 6.5m of high, in which the diameter of media made of quartz sand is 0.3—0.5mm, using air jet for aeration inside the reactor. The test is within the bio-film thickness of 52, 80, 115, 137m, respectively. The BOD₅ concentration in the sewage tested are 47.6—77.2mg/L.

Key words: three-phase biological fluidized bed, rate of expansion, formula based on experimental data, equivalent function, thickness of bio-film, method for design, wastewater treatment.

Study on the Operation Characters of a Modified Two-Phase Anaerobic Digestion System. Guo Yanghao, Men Chun, Shi Xianai et al. (Dept. of Biotechnology, Fuzhou University, Fuzhou 350002): *Chin. J. Environ. Sci.*, **18**(3), 1997, pp. 38_40

In this work the operation characters of the two-phase anaerobic digestion system incorporated by a packed bed acidification reactor and an UASB methanorization reactor were studied. The packed bed acidification reactor started up easily and possessed of a high acidification rate and a good resistance against hydraulic impulsion and pH fluctuation. The COD volume charge was higher than 200 kg/(m³·d). Adopting a preadjusting alkalinity technology, the two-phase system could operate normally and effectively for treating brewing wastewater. Under the conditions of COD concentration 1000—7000 mg/L in the feed and COD charge 40 kg/(m³·d), the COD concentration was less than 200 mg/L in the effluent. The system possessed also a rather good capacity for treating antibiotics wastewater.

Key words: packed bed acidification reactor, two-phase anaerobic digestion system, brewing wastewater of high concentration.

An Investigation of the Subjective Response to the Traffic Noise of an Elevated Highway or

Viaduct. Chen Ziming (Department of physics, Ocean University of Qingdao), Liu Weiming et al. (Environmental Monitoring Centre, Qingdao): *Chin. J. Environ. Sci.*, **18** (3), 1997, pp. 41_ 44

The popular response to the traffic noise of elevated highway or viaduct in the Qingdao City was investigated using simultaneous doing method of questionnaires and noise measurements. The variations of subjective annoyance value and sleep interference rate with the effective noise level was analysed. The difference in the subjective annoyance values and sleep interference rates of population of different groups was pointed out and the difference in their subjective response before and after the construction of an elevated highway or viaduct.

Key words: traffic noise, elevated highway or viaduct, subjective response, subjective annoyance value, sleep interference.

Reformed Methane by Carbon Dioxide over Co/Al₂O₃ Catalyst. Fei Jinhua, Lu Haihua et al. (Institute of Catalysis, Hangzhou University, Hangzhou 310028): *Chin. J. Environ. Sci.*, **18**(3), 1997, pp. 45_ 46

In this paper, the effect of Co content, pre-treatment conditions, space velocity and reaction temperature on the preformance of methane reformed to synthesis gas by carbon dioxide over Co/Al₂O₃ catalysts has been investigated. It was found that Co/Al₂O₃ catalyst with Co content of 13% (wt) (i. e. 13% wtCo/Al₂O₃) showed the best reform activity, decreasing space velocity and increasing reaction temperature improved the conversion of methane and carbon dioxide. Catalysts also showed the best activity at reduced temperature at 400 °C. The CO/H₂ ratio of yields increased with the space velocity increasing, decreased with reduced temperature and reaction temperature increasing. When enough Co content is loaded on Al₂O₃ (eg. 13% wtCo/Al₂O₃), catalysts will appear longer life and stability of activity.

Key words: methane, carbon dioxide, synthesis gas, catalyst, reform, Co/Al₂O₃.

Basic Study on Neural Active Noise Barrier of Distributed & Coordinated Multi-Channels.

Chengxiang Tan and Songling Zhao (The Institute of Acoustics, Tongji University, Shanghai 200092): *Chin. J. Environ. Sci.*, **18** (3), 1997, pp. 47_ 49

The height, material, architecture, weight of the noise barrier are constrained by the landscape requirement and load-bearing frame, which deepens the deficiency of the conventional noise barrier in low frequency wide band noise diffraction and transmission. To im-

prove the performance of the conventional noise barrier, neural active noise barrier of distributed and intelligently coordinated multi-channels is presented. The adaptive nonlinear control vector in time and space domains is self-organized by the proposed compound neural network to drive the distributed secondary sources array optimized. Multiobjectives optimization is adopted. Through training, at first, the neural network optimizes the geometrical distribution of the sensors and secondary sources, in order to synthesize the suitable noise reducing space distribution and reduce the hardware cost; secondly, the structure of the neural controller is simplified. At last, the reserved connection weights get precisely optimized. The scheme is demonstrated to be applicable especially for wide-band and large area noise barrier.

Key words: noise control, noise barrier, neural network.

Chinese Expressway Tunnel Pollution and Control. Wany Mingnian, Wong Hanmin, Guan Baoshu (Dept. of Underground Engineering, Southwest Jiaotong University, Chengdu 610031): *Chin. J. Environ. Sci.*, **18**(3), 1997, pp. 50—53

In order to control air pollution and noise pollution in expressway Tunnel, i. e. Zhong Liangshan Tunnel, Wu Tongshan Tunnel and Qi Daoliang Tunnel were studied, the site test result showed that machinery ventilate control effectively air pollution in tunnel, source of noise is traffic flow, their noise go beyond the values of standard, so it is important to study on technique reduced noise pollution.

Key words: expressway tunnel, air pollution, noise pollution, machinery ventilate.

Experiments on Long Term Stability of Road Tile Made from Chromium-Bearing Slag.

Wang Yongzeng et al (China Institute for Radiation Protection, Taiyuan 030006): *Chin. J. Environ. Sci.*, **18**(3), 1997, pp. 54_ 56

By adding 20% chromium-bearing slag into base materials of making brick, the brick sample was sintered in the required geometric shape under the given temperature. The size of sintered base sample was measured and the associated Cr water solubility test made before and after sintering. The sample was tested in leaching liquid under variable conditions. Based on the experiment results data, the leaching rate is 0.8×10^{-7} cm/d and the accumulative leaching fraction is 1×10^{-4} cm/d, the stability of Cr in base sample was determined and therefore such method of treating chromium slag was considered feasible and practicable.

Key words: chromium-bearing slag, road tile,